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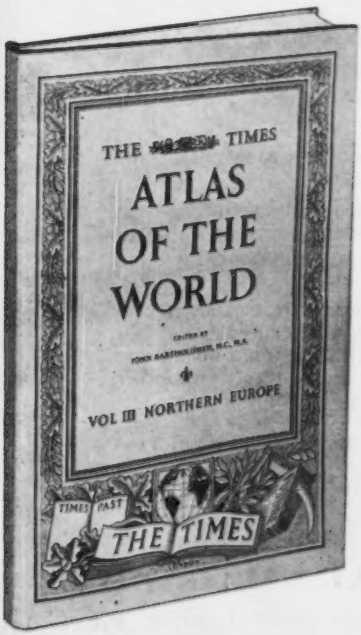

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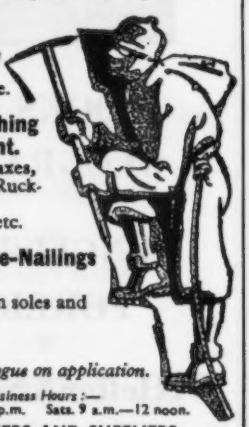

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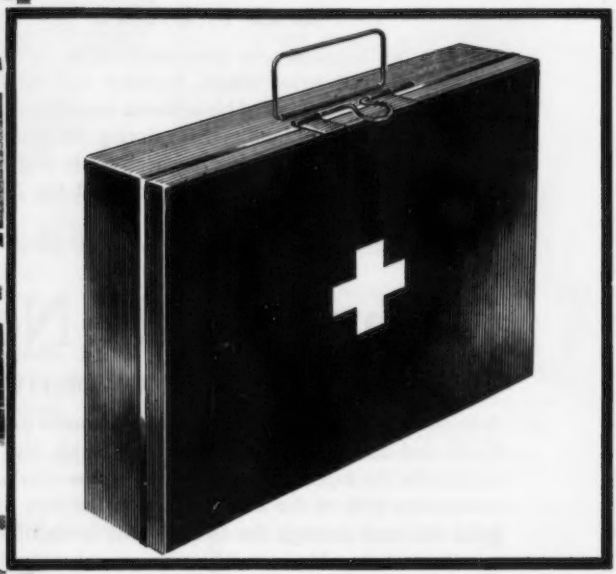

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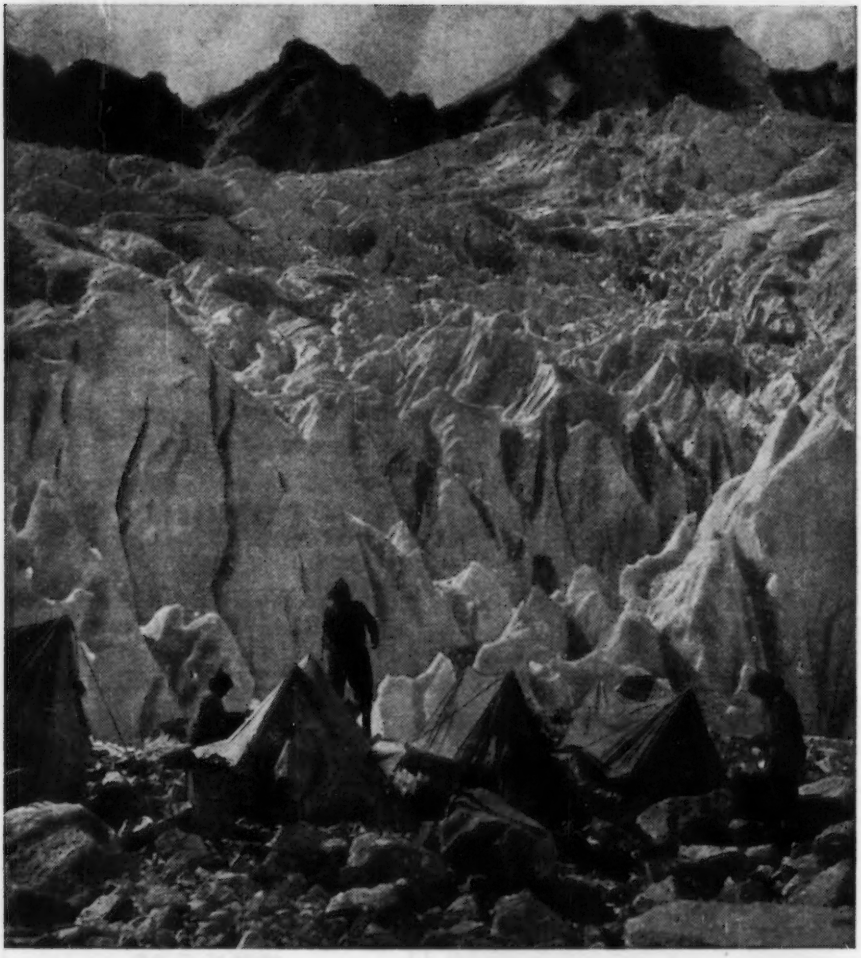

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THE ORDNANCE SURVEY AND THE PUBLIC

MAJOR-GENERAL J. C. T. WILLIS

THE PUBLIC know quite a lot, I think, about the Ordnance Survey, for a selection of our products is available on every bookstall. There is, however, a tremendous lot that the public does not know, and I hope this evening to fill in some of the gaps. My time is short, and I must confine myself to the problem of our large-scale plans, for that is the aspect of our work of which the general public is least aware, though it constitutes 70 per cent. of our whole task.

First let us consider the state of affairs at the outset of our present task; a task with which we were first able to get to grips at the end of the last war. In 1924 the country was still suffering from the First World War, the Geddes axe fell, and the regular revision of the 25 inches to 1 mile survey of this country came almost to a standstill. I must emphasize that the main task of the Ordnance Survey is the production of those large-scale plans of the country which play so large a part in our national economy. Planning, rating, the buying and selling of land, all depend on plans of this scale. The production of the 25 inches to 1 mile plan was—and still is—the backbone of our task. The 25 inches to 1 mile coverage of all cultivated areas of Great Britain was, up to 1914, maintained by full revision on a twenty-year cycle. The complete cessation of all normal Ordnance Survey functions during the First World War, an accumulation of delayed building activities throughout that period, and finally the Geddes axe, meant that this twenty-year cycle could only be implemented in the urban areas—leaving the rest of the country with no planned revision whatsoever. Not even this unsatisfactory compromise could be implemented for long, and it soon became impossible to maintain even the urban areas on this twenty-year cycle. In short, in the mid-1920's the large-scale survey organization of Great Britain collapsed.

It took some time for the true state of affairs to be realized, and I think that this was due to two main factors. First, the conviction in the minds of so many that maps "just happen," and, having happened, automatically remain up-to-date. The second factor, which tended to obscure the real facts of the case, was that the quality of the maps most in the eye of the public—*i.e.* the 1 inch and $\frac{1}{4}$ inch to 1 mile series—remained relatively unaffected in their reputation as the best in the world. Finally, however, the true state of affairs was realized and a Departmental Committee under the chairmanship of Lord Davidson was appointed in 1935. This committee carried out a most sweeping investigation, but unfortunately the implementation of its far-reaching recommendations was forestalled by yet another World War. This war, as in the previous case, brought all normal Ordnance Survey

activities to a standstill. The Department did not, however, waste its time, for it produced, during that period, nearly 200 million maps for Service requirements. But it was not until 1945 that a serious start on the problem could be made and, of course, by this time the situation had again deteriorated, not only by the complete diversion of Ordnance Survey resources, but by the enormous increases in building which were put in hand at the end of the war, and which are still going on today.

The Davidson Committee, whose findings were later to some extent modified and as such accepted by Parliament in 1945, made many important recommendations:

1. That the 1/2500 scale should be retained.
2. That the 1/2500 survey should be recast on national instead of county sheet lines on a national projection, and that, while this work is in progress, there should be a general overhaul of the plans to eliminate the errors which have crept into the original survey in course of revision.
3. That a National Grid should be superimposed on all large scale plans and on smaller scale maps, with certain exceptions, to provide one reference system for the maps of the whole country.
4. That the international metre should be adopted as the unit on which the grid should be based.
5. That the large-scale maps in the new National Series should be square in shape.
6. That the 1/2500 plans when republished in the new National Series should cover 1 kilometre square of country.
7. That the 1 inch to the mile and smaller scales should be retained in their existing form.
8. That the existing 6-inch plates should be retained for printing on demand for special purposes.
9. That the scale of 6 inches to 1 mile should be retained, and that maps on this scale should be produced in the new National Series in a square shape and containing twenty-five 1/2500 plans.
10. That a new medium scale of 1/25,000 should be tried out experimentally in certain selected areas, and, if successful, should be extended to cover the whole country in a National Series.
11. That when the revision of the 1/2500 plans has been completed, further investigations should be carried out with a view to establishing whether the requirements of urban areas would not be more adequately met by a survey on the 1/1250 scale.
12. That when a suitable opportunity occurs, additional contours should be introduced.
13. That the numbering of parcels should be discontinued as soon as the National Grid is introduced.
14. That the Ordnance Survey should continue to publish archaeological maps.
15. That the existing arrangements for revising the 1-inch and smaller scales should continue.
16. That a system of continuous revision should be adopted for the large-scale plans as soon as practicable.
17. That short term contracts to civil firms, for aerial photographs, should not be continued as a permanent policy and that the Government should consider the formation of a special air survey unit, capable of satisfying the require-

ments of the Ordnance Survey. It was emphasized that, in view of the potential value of air photography, it was desirable that such a unit should be created as soon as practicable.

18. That the position of the Ordnance Survey should be reviewed annually with a view to the maximum practicable recruitment, until such time as the recommendations we have embodied in this report have become effective, and that thereafter such work should be adequately maintained.

On this occasion I must concentrate on the effects of only two or three of these recommendations. First, the institution of a completely new large-scale plan at 50 inches to 1 mile to cover all the major towns of the country. Second, the resurvey or overhaul of the entire 25 inches to 1 mile plans of Great Britain. These two recommendations involved the survey of every large town at 50 inches to 1 mile, and the overhaul of all cultivated areas at 25 inches to 1 mile.

One other recommendation of the committee is I think the most important of them all. It is that both the above series should be maintained in a state of continuous revision, so that never again would the surveys collapse through inability to continue a cyclic revision, and never again would the capital sunk in the original survey be thrown away as areas became so out-of-date that they could no longer be revised. The committee went on to record that a National Grid should be superimposed on all large scale plans, and on all smaller maps—with trifling exceptions—to provide one overall reference system for the whole country, and furthermore that the new large-scale plans should be recast from their county sheet lines into a completely new system based on the National Grid.

The overall effect of these recommendations was, in addition to the requirement for continuous revision of all of our large-scale plans, to confirm the need for the existing coverage of Great Britain at all scales—and indeed to suggest one new one. Thus we were faced with the map coverage of this country on scales of 50 inches to 1 mile, 25 inches to 1 mile, 6 inches to 1 mile, 2^1_2 inches to 1 mile, 1 inch to 1 mile, 2 miles to 1 inch, 4 miles to 1 inch, 10 miles to 1 inch, 1/1M., as well as archaeological maps and other special productions. Incidentally, for simplicity's sake, I have up to now referred to these scales by a slightly inexact colloquialism, rather than by a representative fraction. At this stage I should like to draw your attention to a departure which has been found necessary. You will see that the provision of 1/1250 coverage was suggested upon completion of the revision of the 25 inches to 1 mile scale. It was, however, discovered very soon that the cost of field survey at 1/1250 was little—if at all—greater than at 1/2500. Furthermore, that the areas in which 1/1250 was required were just those areas in which the need for revision, or resurvey, was greatest. Hence it seemed logical to survey at the larger scale which we knew would ultimately be required, and to produce the smaller scale from the larger by photomechanical reduction.

In turning now to the more detailed description of how the task laid upon us was planned and set in motion, I feel myself doubly in the position of stewardship—not only to you who foot the bill and expect the results, but also to those, my predecessors, who designed and built the ship and launched her down the slipways. The first task was, of course, the completion of the major and secondary triangulation of the British Isles. This task, thanks to the foresight of others, had been well begun in 1935. It is now substantially complete. The next task was to decide on new methods and modern instruments and materials for the actual survey work to be done. Much of the shakiness discovered in areas of the old 25-inch county

series coverage was caused by the fact that original drawings had been made on unstable material such as paper; this shakiness was increased by the then need for complete redrawing of the entire sheet on each and every occasion that a new edition was published, with the inevitable tendency for errors to propagate themselves in the process. It was clear that the elimination of this method was vital, on the grounds of its utter wastefulness in time and money alone, quite apart from ensuring against any recurrence of the gradual creep of errors. These problems were solved, both in the case of original survey and subsequent revision, by the introduction of new techniques and processes relying on the use of non-distorting materials throughout the field and reproduction processes.

At the earliest stage in the task we have the introduction of aluminium butt-jointed plates for the original field survey. These plates are assembled in groups of four in a special container suitable for the use of the field surveyor. Not only is all possibility of distortion eliminated from the base on which the original survey is drawn, but also those errors which were always liable to arise when working on the extreme edge of a plan were also disposed of, since it is obvious that the constituent plates can always be assembled in such a way that the surveyor can work in approximately the middle of his area. Hence, from his point of view, plan edges cease to exist. The fair drawings made subsequently from the field work, are carried out on enamelled zinc plates, subsequently to be photographed on to heavy glass negatives. Throughout the whole process, whether that of original survey, or of revision, non-distorting materials are employed, and the use of paper has been completely eliminated.

The introduction of the new 1/1250 did not involve as many problems on the field survey side as might be assumed at first. Although a given area requires four times as many plans as at the original scale of 1/2500, the time and manpower required proved to be much the same for each scale. There is not a great deal of difference in the amount of detail to be shown, and it seems that the work of supplying the additional detail on the larger scale is offset by the extra time spent in measuring and plotting the intricacies of the detail on the smaller scale. Four times the actual number of plans have—in the end—to be produced on the 1/1250 scale in order to cover any given area of ground; five times that number if one counts also the consequential 1/2500 plan made photo-mechanically from reductions of the original 1/1250. It must be recalled that all these plans at 1/1250 must also be kept under continuous revision to an ultimate total number of 38,000, for the major towns of Great Britain alone.

Turning now to the problem of the 1/2500 scale, you will remember that the Davidson Committee recommended that these should be "overhauled." The Committee, however, refrained from saying what it meant by the word "overhaul." Here again, experiments and tests were carried out in every method which could be thought of, and have finally resulted in the adoption of a technique which enables a plan to be "overhauled," any previous shakiness largely eliminated, revised to include all new developments, and republished to National Grid specification and sheet lines in roughly one-sixth of the time which would have been involved in the preparation of a new and original survey. The method has been proved to our complete satisfaction but, owing to the higher priority now allotted to the 1/1250 scale in urban areas, it has not yet been carried out to any great extent except where it is urgently required for the correlation of the underground surveys in the mining areas and, to a limited extent, for experimental purposes elsewhere. The ultimate total number of plans at 1/2500 will be just short of 200,000.

Let us now consider the problem of continuous revision. This implies that as soon as an area is surveyed on 1/1250 or 1/2500 scale, and the original surveyors themselves have moved on elsewhere, a sort of permanent rear party is left behind, whose job it is to keep the survey continuously up-to-date as new developments occur. The present rule is that no single plan shall have more than three surveyor-days' work outstanding upon it, and further that the total work outstanding shall not exceed, in the aggregate, more than one day's work per plan under continuous revision. We have thus guarded against any large accumulation of survey work waiting to be done, and against the danger that the survey of the country will again become out-of-date.

The problem of when to publish the results of our field survey is, however, always with us; somehow we must balance the public need for completely up-to-date plans against the uneconomical proposition of scrapping an existing edition and republishing a new one every time a new house is built on any plan. It is solved, at present, by the operation of a yardstick, based on a combination of the extent of new development on any sheet and the time elapsed since the last edition. This is supplemented by a special advance information service, which will supply tracings up to the minute for users who really need that information and, incidentally, are prepared to pay for it.

Time does not permit me to deal in any great detail with more than these main points of the committee's recommendations. It must be remembered that they are not the only tasks and that their fulfilment involves other processes scarcely touched upon this evening. For instance, in all major town areas the existing triangulation framework must be broken down from secondary, tertiary, to fourth order, to provide the traverse control necessary. We have at the moment on this task some sixty-five traverse parties operating in the field.

In addition to the instrumental control required, we must not omit some reference, which can be little more than very slight, to the levelling problem—from geodetic lines and fundamental bench marks down to the spot elevations which play their part in the production of the completed plan.

Progress demands new methods; new methods demand new tools, and I should like to refer to just a few of these. One is the introduction of tacheometers and radial line plotting, which shows very considerable saving in just those areas where survey by traditional methods is most difficult, and hence most expensive. Another is the increased use of air survey plotting machines and photogrammetric triangulation. This subject would need a special lecture to do it justice, and suffice it to say that savings by the use of modern techniques are, in some cases, nearly 50 per cent. on our traditional methods. In particular we are glad to welcome for the first time the presence on the market of a British-designed and British-made precision plotting machine. Its presence, and our ability to purchase the number we require, may well have a tremendous effect upon our rate of output. Our air survey methods are used, of course, in association with preparatory work in relation to the Decca tracking by which the actual photography is controlled. Further new methods include the use of the electronic brain at the National Physical Laboratory for our photogrammetric triangulation computing, of infra-red photography for the provision of tidal information, and of walkie-talkie apparatus to enable our triangulation parties to express their views to the distant light-keepers with greater fluency and emphasis than is possible in the Morse Code.

The introduction of electro-mechanical computing and punched cards designed for all our tertiary levelling computations and for our traverse computations is also

desirable, procedures which are applicable to our secondary and tertiary triangulation as well. Considerable saving in time and manpower can be affected by the development of an electro-mechanical instrument which will scan the parcel areas on our 25-inch plans, and reduce them automatically to the acreage required. The introduction of scribing, that is, the cutting away of a masking substance with a sharp instrument, will, in my opinion, shortly replace the use of pen and ink for drawing throughout the Department, and should enable relatively unskilled draughtsmen, possibly even the field revisers themselves, to produce work which is capable of reproduction without the intervening stage of fair drawing. So much for the tasks; and so much for the methods.

Let us now take a look at our present progress, up to the end of 1955:

New 1/1250	52 per cent. completed out of total of about 36,000 plans. 74 major towns completed. 86 in hand. 118 smaller towns not yet taken up.
Overhauled 1/2500	Nearly 6 per cent. completed out of about 186,000.
6 *inches to* 1 *mile:*	
Provisional (*National Grid*)	13 per cent. out of about 9,500.
Regular	1 per cent. out of about 9,500.
1/25,000:	
Provisional Edition	All Great Britain, except the Highlands of Scotland, completed.
Provisional Edition, revised	About 40 per cent. of approximately 2,000 sheets.

You will see how long a time must necessarily elapse before the task is completed. An obvious remedy for this slow progress, and for the long time which must elapse before the survey is completed and the whole country is under continuous revision, is more money and more men. Problems of this nature are, of course, a matter of national policy, and there is little we can do about it, except to accept loyally the decisions of those with greater responsibilities and wider knowledge than ourselves, and to make the best use of what we have got. This best use is, of course, the adoption of modern men-and-money saving techniques, and though we are far from complacent I think we can reasonably claim that we have not been entirely blind or idle in this matter.

So far this talk has confined itself to the half of its title which refers to "The Ordnance Survey." Now what of "The Public?" It is one of the most difficult parts of our task to assess what it is that the public really wants; indeed, to find out who "The Public" really are. I have carried out some researches into "The Public" and have reached some conclusions as to what it really is. We receive from the public some 10,000 letters a year, and it is on a selection of these letters that the following analysis is based. It is completely satisfied, but complains bitterly. It knows exactly what it wants, but is not sure of its requirements. It regards us as a most efficient organization, but feels we are completely incompetent. It feels that our products are vital, but wonders why we bother to make them. It thinks that our maps are excellent value for the money, but that they ought not to be so expensive. It knows nothing about the science of map-reading, but is always ready to advise a department which quite obviously does not know its own mind; and, of course, it always lives at the junction of four sheets! More seriously though,

we are in constant touch with our users through many channels, trying to find out where in their opinion we succeed, and where we fail; what we are failing to give them that they want, what we are perhaps giving them that they do not want and sometimes, all too often, what they want but cannot have. We have lately completed the analysis of a carefully worded questionnaire sent out to selected local authorities throughout the country. As so often happens, the results are far from conclusive. Each society, nay, each individual seems to have an extremely clear view of its own requirements and a readiness to overlook the needs of others, which we can envy, but may not share. A motoring society will want all railways shown in a thin invisible pecked line. A pedestrian society wants footpaths shown against a faint grey background of everything else. The council of a town—newly surveyed at 50 inches to the mile—wants the whole area covered again at 120 inches to the mile. The town whose plans are thirty years out-of-date, however, has no doubt at all what it wants, and no difficulty whatsoever in saying so! Teetotallers want all the inns omitted; others, a differentiating symbol between beer and spirit licences. Some, having used the map, want their money back. Many letters point out real or imagined errors in our work. Most of them are appreciative. Many pay us the high compliment of being both horrified and abusive if there is the slightest suggestion that we may perhaps be in error. Incidentally there has for long been a rumour—and it dies hard—that a fee of one guinea is paid to anyone who successfully challenges the accuracy of any point of detail in a published Ordnance Survey map. I hope that this present moment may be an opportunity for me to knock one more nail into the coffin of this myth.

In parenthesis, might I mention that last summer a postcard was received from a group of hikers who had walked many miles over Dartmoor to a spot marked "INN" on a 1-inch map. They had planned their arrival to coincide with opening time, but when they reached their destination they found that the licence had been suspended some ten years previously; the word "INN" on the map had unfortunately not been deleted. Their emotions were such that their letter of complaint was written throughout in rhyming verse! An immediate reply, however, was sent, reading as follows:

> "The Ordnance Survey is the first
> To deplore an unslaked thirst,
> But the next time, without a doubt
> You'll find the absent 'Inn' is out."

They must, I think, have wondered what sort of government department they had made contact with.

Before we leave the problems of "The Public" there is one point which I would wish to make, on a more serious note. Ordnance Survey maps are expensive things to make. Their cost is, however, justified on national economic grounds. But, to secure the maximum justification for this expenditure, they must be put to the maximum use; and any form of duplication of our efforts by others can only be a waste of money. I am not personally interested whether the money be the taxpayers', or the ratepayers': we are all of us both! Similarly, the economic advantages of their existence must be used to the full. For example, it seems to be generally agreed that the registration of ownership of land is a good thing. Land registration is, from the survey point of view, astonishingly inexpensive wherever our new National Grid plans exist. It is arguable that land registration might well be made compulsory in all cases where the new survey has been done. There

is a corollary to this argument, on which I think I would be well advised not to dilate!

We have had a quick glance over our task. May I for a few moments allow myself a peep into the future and a guess at what may well be the situation in some surveyors' Utopia, possibly only a decade or two ahead. Theodolites, but with no written observations in the field; intersections will still be made by hand and eye, a button will be pushed, a hole in a card or tape will be made, and the entire series will find its way into electronic computing machines, which will provide the answers with little further human intervention. The same, of course, will apply to levelling. All drawing will be carried out in the field by scribing—the cutting away of a light-resisting surface—by specially constructed tools. The pen and ink will be no more in use. The fair draughtsman as such will be available for employment elsewhere. Continuous revision will mean just what it says, and every *plan*—not every edition as now—will be brought up-to-date to the minute and individually reproduced for handing over to the customer. All these ideas will involve, not survey unemployment, but a better application of our manpower to make fuller use of its skill and craftsmanship and a fast and efficient national survey.

DISCUSSION

Evening Meeting, 12 December 1955

Before the paper the PRESIDENT (General Sir JAMES MARSHALL-CORNWALL) said: We are privileged tonight to have to lecture to us the Director-General of the Ordnance Survey. The Ordnance Survey is a very respectable institution, almost venerable; its foundation preceded the foundation of our Society by quite a number of years in that it was founded in 1791. In the year 1745 the Scottish members of our United Kingdom were dissatisfied with the Hanoverian succession and there was a certain resistance movement. The British Government decided that they had not studied sufficiently the geography of Scotland, and there was a certain Captain Roy of, I think, the Royal Engineers—at any rate he was employed by the Board of Ordnance, a mysterious Government department independent of the War Office which controlled the destinies of the Royal Artillery and the Royal Engineers, the scientific branches of the Army, and it was the Board of Ordnance which instituted the Ordnance Survey in 1791. This Survey then proceeded methodically to carry out a trigonometrical survey of the whole of the United Kingdom. That work, which has been continued ever since with more or less support from different British Governments, has resulted in the United Kingdom being today the best mapped territory in the world. General Willis will give us a general impression of how the Ordnance Survey does its work and the great effort which it makes to meet the requirements of its users.

As I have said, the Ordnance Survey was, first, under the Board of Ordnance; it was then independent of the War Office but was eventually integrated into this department. Later it was transferred, from being a purely military organization, to the Ministry of Agriculture and Fisheries. The main purpose of the Ordnance Survey is not military, although it is of tremendous value to the soldiers of this country to have an accurate map available. We found that out when trying to plan the operations of the Home Guard some years ago! But the Ordnance Survey does also serve the purpose of many other users of maps.

The Minister of Agriculture, Fisheries and Food has, unfortunately, at the last moment had to decline our invitation for this evening, but we have with us his representative, the Director of Organization and Establishments, who has consented to say a few words after the lecture. We will also have the opportunity of listening

to one of the main users of Ordnance Survey maps—the Senior Planning Officer, Architect's Department, London County Council

Major-General Willis then read his paper.

The PRESIDENT: I think that the country, which owns the Ordnance Survey of Great Britain, will be very satisfied that it has as Director-General Major-General Willis. He is not only a very competent professional geodetic surveyor, but is gifted in other ways, for instance, as an artist. The productions of the Ordnance Survey do present a balanced artistic appearance which owes a great deal to the present Director-General. General Willis also has a sense of humour, very necessary in dealing with so many Government departments. Added to this, he has a marked sense of proportion, most essential in one who has to hold the balance between the production of maps on the scale of 1/1,000,000 (which means 16 miles to the inch) down to the scale of 1/1250, or 50 inches to the mile. The combination of those qualities has produced, and will continue to produce, the best maps to be seen in the world. I now call on Mr. Oake, Director of Establishments, Ministry of Agriculture, Fisheries and Food, who is representing the Minister this evening.

Mr. G. R. OAKE: It is most unfortunate that, owing to the pressure of inescapable public duties, the Minister could not be with you this evening. The Minister wishes me to say that he is most sorry that he cannot be here to add his tribute to General Willis and to the Ordnance Survey. I have enjoyed listening to his account—of necessity very much compressed—and I hope many of his listeners may accept the invitation he held out to visit the Ordnance Survey and see for themselves on the spot. His invitation was deficient only in one respect: it seems to be that an audience, even of geographers, would like to be told where they should go and how to get there —you go to Chessington and ask for the Zoo!

My first official contact with the Ordnance Survey had to do with the need for new premises to enable them to be drawn together, as a department, from their present three scattered homes, and to be given an adequate building. I am most impressed by the way in which the department maintains its very high standards of printing and production under extremely difficult conditions and in inconvenient premises. In spite of General Willis' great modesty, what is plainly to be seen as he speaks is the extraordinary readiness of the Ordnance Survey to adopt and adapt new methods. That degree of liveliness of mind and readiness to take on something fresh would be striking in any Government department, but is even more so in one which is deeply conscious of the need for continuity and is devoted to a task requiring patience, accuracy and a large measure of detail.

The PRESIDENT: We have heard the map-maker and the representative of the responsible Ministry. We have also with us a representative of the Architect's Department of the London County Council, and I ask the Senior Planning Officer of that Council, Mr. Lane, to speak.

Mr. L. W. LANE: When I was asked to say a few words about Ordnance Survey maps, I was nonplussed. I was sought by one of your members whilst en route from one committee meeting to another in the precincts of County Hall with a roll of plans under my arm, and asked if I would come here tonight. It is rather as though I were in the kitchen at home having a drink of water, and someone burst in and asked if I would propose a toast to the Water Board. One does so tend to take essential services for granted, and so I was very pleased when I was made to think about this problem.

In 1947 there was passed the Town and Country Planning Act which put upon local planning authorities the duty of carrying out a survey of their area, and preparing a Development Plan which would indicate how the land in this country should be used. By now most of those Development Plans have been prepared, and a large number of them have been approved by the Minister of Housing and Local Government. They probably affect everybody within this room, either as members of the

public or as owners or occupiers of property. The foundation of those plans is survey, and in this context I use survey in a very different way to that in which it was used by your lecturer this evening. By planning survey, I mean a kind of sociological survey. It is obvious, however, that if the planners of this country had to carry out basic land surveys then we should never even begin making our plans for preserving the amenities of this country. So that we take for granted the production of the large-scale plans talked about this evening. I would like to give a brief idea of the process which goes on. To carry out our planning surveys we had, first, to engage a staff, and so we advertised in the press. The main applicants were young fellows who were field surveyors from the Ordnance Survey; when asked why they wanted to leave the Survey, they said they had to go long distances away from home and wanted to be in one place for a while. I regret that I had to filch staff off you, Sir, but I may say that many of them have now gone on to take the postal exams and have been very successful in the field.

We have to go out with the Ordnance Survey in our hands and find out, and mark on the plans, a whole series of data, so that we have layer upon layer of sociological information; for instance, the use of land, and the residential density. In this latter respect we get some data from the Census and by combining that with the Ordnance Survey we are able to ascertain the density at which people live; we can also find out data on overcrowding and matters of that kind. Further, we can trace from successive editions of the Ordnance Survey the growth of towns, and this is a job which could not be carried out in any other way. In detail, we can trace the growth of the central area of a town such as London. We are all very conscious in these days of the tremendous congestion in central London, and in considering that problem we can show the degree by which, from the beginning of the present century, central office uses have been creeping out to the residential areas. All these kinds of data can be revealed by the comparison of Ordnance sheets of different dates. From these surveys, as we analyse them and set one against the other, we begin to see how a town works and so evolve proposals for the future development.

I am speaking as one concerned with a great urban area but there are similar problems in the countryside where different scale maps are used; nevertheless, the process is very similar to that which I have outlined. But there is a danger, so good are the maps with which we are supplied, that planners may be tempted to rely on the maps alone, and that we may get out of touch with reality. We can guard against this by making models of our proposals; and the public and the committees whom we planners serve can appreciate our proposals far better if they are presented in model form. Here again we turn to the Ordnance sheets, with their levels and contours, from which we can build a three-dimensional picture of our towns and their proposed development.

General Willis, I was delighted to hear you speak about the proposal for constant revision. That is absolutely essential to the country's economy, and I can certainly say that if it is not carried out by the central department it would have to be done by local authorities, which would be far less economical. I had hoped to be able to give the total number of maps consumed by the London County Council during the course of the year, but I was told it would be most inadvisable to give it in public because we have to pay royalties on the maps! At any rate, it runs into many thousands and of course the function with which I cope is only one amongst the many activities of a local authority. Now, Sir, it is a thrill for me to come onto this platform this evening and to pay tribute to you and your staff for the wonderful work that is being done today. I speak as one who has lived with maps for many years—as a chartered surveyor, as a town planner, as a junior sapper officer in the War, as a motorist and as a hiker. In all those capacities I have known and loved maps and am grateful to the Ordnance Survey.

Lord RENNELL OF RODD: At the beginning of the War the signposts were removed in order to deceive the Germans should they land; it also occurred to somebody to

remove most of the milestones and in the process a number of bench-marks were removed. That certainly happened in my rather remote part of the country and towards the end of the War the County and Borough Councils decided to replace the bench-marks, but not necessarily in the precise places from which they had been removed but, anyway (as they thought) near enough. Can General Willis say what happened to the bench-marks which were so removed?

General WILLIS: That is rather a difficult question. I was not there at the time.

Major-General R. LL. BROWN (ex-Director-General of Ordnance Survey): It was before my time too. But I can assure Lord Rennell that steps were taken to erase the bench-marks from milestones that were known to have been removed and later replaced in the way he describes. However, any that may have been missed will certainly be picked up and either erased or given a new level value when the periodic relevelling reaches them. Now I am on my feet I would like to say how much I have enjoyed listening to General Willis. I am one of those who know a lot about it, and to me what he said was intensely interesting. I was delighted to hear him pay a tribute to the staff of the Ordnance Survey. I have had many staffs in my time and I think the spirit of the Ordnance Survey is one of the finest I have known.

General WILLIS: Arising from what Mr. Lane said, I would like to make one point quite clear. He said he was glad to hear of our proposals for continuous revision: I wish to make it perfectly clear that this revision is far more than a "proposal"—it is a going concern, and has been for many years.

Mr. LEONARD BROOKS: I gather that the 2½-inch map is rather in danger; it seems to me that it would be a very serious loss, because in schools it is one of the most important of the Ordnance Survey maps, and one of the prescribed set for the General Certificate of Education.

General WILLIS: I am glad my remark in that regard has started something. I read out a complete list of all the coverage we have, from 50 inches to a mile to 1/1M. Our budget is not conditioned to a task of that sort, and I love to hear the general public complain that there is something which we think of taking away from them which they say they cannot do without! The 2½-inch to a mile may well be one of the maps which we can no longer maintain; I do not know what are the channels for drawing attention to the inadequacies of the Ordnance Survey if starved of the tools of its trade, but I think you need have no immediate anxiety.

Mr. R. A. SKELTON (British Museum): I would like to underline what has been said as to the reputation of the Ordnance Survey overseas. The display of its work at the Geographical Congress at Washington in 1952, among the maps from different national surveys there exhibited, caused what may fairly be described as a sensation. I speak as one who uses Ordnance Survey maps a great deal. In the Map Room at the British Museum, a great many people study Ordnance Survey maps of all scales and all editions. I find that a large proportion of those people (and I do not think that many of them are hikers) are using the 2½-inch map. It is not a map merely for teaching nor merely for hiking, but a map which combines the details of the large-scale plans with the convenient coverage of the small-scale maps. It is, for instance, the smallest scale map on which field boundaries are marked. Although I understand that sales have been small, I think the loss of that map would be very much greater than could be measured by the number of people who actually use it, because most of them are members of the teaching profession—not only schoolmasters, but also university teachers and research workers.

The PRESIDENT: I am sure the Director-General will take to heart the words of the Superintendent of Maps at the British Museum. In drawing the meeting to a close I draw attention to the fine exhibition of the work of the Ordnance Survey in the Society's exhibition gallery. There can be seen the latest Ordnance Survey maps and the whole process of reproducing the maps from the original aluminium sheets used in the field with control triangulation points upon which the whole triangulation is based, and on which the field surveyors fill in detail on the spot.

LAKE VAN AND TURKISH KURDISTAN: A BOTANICAL JOURNEY

P. H. DAVIS

THE SOUTH-EAST corner of Turkey has always been one of the least known parts of Asia Minor; wild and mountainous, sharing a frontier with 'Iraq and Persia, it is both physically and politically difficult of access. But in the summer of 1954 permission was granted by the Turkish government for me to extend my botanical researches into that area. The small expedition was made under the auspices of Edinburgh University. I was accompanied by Mr. Oleg Polunin, who had been on two expeditions to Nepal, and by Mr. Aydin Bilgutay, a medical student from Istanbul who acted as our interpreter. The primary purpose of our journey was botanical exploration. Turkey has a very rich and comparatively little known flora. Not only does it possess a high percentage of endemics (species confined to Turkey), but it is also on the migration route of the Asiatic flora, part of which has penetrated into Europe by way of Anatolia.

Before I begin my account of what used to be called Turkish Kurdistan and the adjacent part of Armenia (I use the names only in a geographical sense), a few remarks on the general topography of Turkey will not be out of place. Anatolia is bounded to the north and to the south by mountain ranges; between these two barriers lies the Anatolian plateau, cut off by the mountains from much of the rain generated by the Black Sea and the Mediterranean. The plateau has a severe winter, with snow often lying for months; humidity—especially in the summer—is very low, and is the limiting factor that separates the steppe flora from that of the Mediterranean forest and maquis in the south and west parts of the peninsula. In the north, the demarcation of the steppe flora from the rain-soaked forests of the Black Sea, choked with alder and rhododendrons, is abrupt and spectacular; the Pontic Taurus forms a very effective cloud barrier.

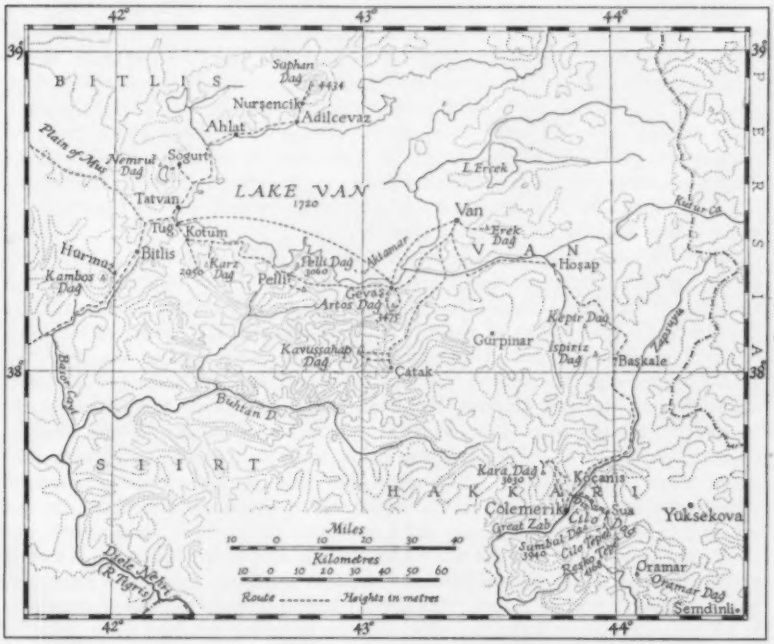
Several factors, in addition to low rainfall and humidity, and extreme winter cold, affect the vegetation of inner Anatolia. Dry winds torture the soft rocks of the plateau into weird forms; violent hailstorms help to erode it away; goats, sheep and camels severely graze the vegetation. The commonest plants are usually those that can best resist excessive grazing—either because they are unpalatable or because they are protected by an armature of spines. Many of the plants that do not possess these features find a foothold in the crevices of cliffs where they are comparatively free from grazing and obtain a stable water supply in the deep fissures of the rock. The botanist looking for rare plants must comb the steepest places.

We reached Lake Van by Land Rover at the end of June, having motored from Ankara by way of Kayseri and Malatya. In the south-west corner of the lake, at Tuğ near the old harbour of Tatvan, we found a new hotel that was clean and spacious, and service which, though inadequate, was well meant: an excellent place for a botanist, encumbered by flower presses, to use as his base.

Lake Van, lying at 1720 metres, has no outlet and contains a high percentage of alkaline salts; the soda content is about 2 per cent., being present in the form of sodium chloride, sodium carbonate and sodium sulphate. There are no fish in the lake except for the endemic *Chalcaburnus tarichi* ("Tarekh"), which is very abundant

where rivers flow into the lake. The fish are caught in spring when they migrate up the rivers to spawn; they are salted by the inhabitants to form an important winter food. On one occasion, looking down on the lake from a cliff near Adilcevaz, we saw a large water snake swimming close to the edge, far from any river mouth; it eventually swam down out of sight into deep water.

The southern shore of the lake shows at least two well-marked raised beaches, one at about 50 metres, the other at nearly 100 metres; these terraces, often clearly marked by differences in the scrub vegetation, are occasionally punctuated by caves—presumably the effect of wave erosion when the waters stood at a much



higher level. Lynch suggests that water from the lake once flowed into the adjacent Tigris (as claimed by Pliny) and that this exit was blocked by outflowing lavas from Nemrut Dağ—the lava plateau that now separates Lake Van from the lacustrine plain of Muş.[1] The result would have been a marked rise in the level of Lake Van. However, we saw extensive evidence of glaciation in the mountains to the south of the lake, and it would be interesting to know if the two major terraces could be related to climatic changes of the Pleistocene.

The water of the lake is extremely buoyant and cleansing; one emerges from it as clean and slippery as a salmon. It is fabulously blue, an enamelled desert of water surrounded by a barren landscape of snowy ranges and extinct volcanoes. Blocks of pumice float in the water, and specks of obsidian spangle the dark sand

[1] Lynch, H. J. B., 'Armenia,' vol. 2. London, 1901.

of its shore—probably brought down from the old crater of Nemrut Dağ where we found it in abundance.

We made some preliminary sorties into the countryside near Tuğ, climbing a spur of Karz Dağ from the little Armenian church at Kotum. At the end of June crimson peonies (*P. arietina*) were a wonderful sight in the limestone ravines. But at this season of the year, at nearly 2000 metres, even the steppe was still a flower garden: mulleins, pinks, yellow skullcaps and violet catmints, sage, vetch, a rosy bird's foot trefoil and numerous genera unfamiliar to us in western Europe kept us busy with flower press and camera. At the hotel we changed thousands of sheets of damp blotting paper, recruiting a gaggle of small boys to dry it for us in the sun.

Our first serious climb was Kambos Dağ near Bitlis. The old town of Bitlis is a place of great character and solidity, with mosques and minarets decidedly Persian in character. Here "the infant Tigris," as Murray's Handbook of Asia Minor (1890) picturesquely puts it, "breaks into rapids and cataracts in its passage through the town." In winter, snow lies deep for months, only the tops of the telegraph poles sticking out of the drifts; everyone stays indoors and wolves prowl down the main street. Still centre of a *vilâyet* (administrative province), it is a town in eclipse; Tuğ, busy, new, still little more than a shanty town on the shore of the lake, seems likely to replace Bitlis as the centre of life on the western side of Lake Van. A railway from Malatya has nearly reached it.

From Bitlis we drove our Land Rover to the foot of Kambos Dağ, 20 kilometres to the south-west down the gorge of the Tigris. Here it may well have been that the relics of the Ten Thousand marched through, after they had been harried by the Carduchi—progenitors of the Kurds. We walked to the hamlet of Hürmüz, bowered in walnut groves. How similar these mountain villages are, from the Atlas Mountains to Afghanistan: the little flat-topped cottages built of rough-hewn stone, the tiny unglazed windows, the thorn hedges, the walnut tree (or mulberry) by the communal spring. Two elderly Kurds, in home-spun pantaloons, brought us bowls of *ayran*—a most refreshing drink made by mixing yogurt with iced water. Thus fortified, we set off on a stiff, hot climb up the crumbling limestone slopes, aromatic with thyme, into a wilderness of screes and pinnacles. It was our first hard climb of the season and I remember little except for the glare, our thirst, and a snake that shot out while I was pulling up a plant. When one is feeling extremely tired, collecting can become almost an automatic reflex: one returns to base with flower presses bulging with hundreds of specimens (several of them new to science) but with only the haziest recollection of having gathered them.

At the beginning of July we paid a visit to Nemrut (Nimrud) Dağ, the squat extinct volcano that rises to the north-west of Tuğ. We drove to the tiny village of Sogurt, built of black lava; here the women wore scarlet dresses as though to defy their sombre surroundings. It reminded me of similar places in the Jebel Druze. Rumours that we could drive our Land Rover right into the crater—and out again—proved to be well founded. The outer slopes were gentle, and at about 2600 metres we drove the car over the rim and left it by a large snow patch. Nemrut Dağ is described by Lynch (who first mapped it) as having one of the largest perfect craters in the world, being nearly 8 kilometres across. That may be so, but it must be admitted that the effect, when you are *in* one of the largest craters in the world, is not as impressive as you might expect. The view is decidedly circumscribed. The Quaternary crater of Nemrut Dağ contains one large lake, nearly filling half the crater, and four small ones by which shepherds were grazing their flocks; one grand old man in a turban was busy shearing. There were holes in the ground

Peonies [Paeonia arietina] *on Karz Dağ*

Old Van seen from the Castle

South coast of Lake Van, between Tuğ and Pelli. Scrub oak on hills

through which hot sulphurous gases perpetually belched. The flora was limited, but interesting. Lava plugs were colonized by aspen and birch—the only time I have seen the latter (a northern tree) in Turkey. On the rim of the crater we gathered a new, yellow-flowered species of flax which we were to find on all the mountains we climbed in this region. It is related to a species confined to the top of Mount Hermon 700 kilometres away.

From Tuğ we decided to drive to Van by a little-used track along the southern side of the lake. Most of the traffic from Tuğ to Van goes by steamer (of which there are four on the lake) or by the long road round the less mountainous northern shore. But we had set our heart on the southern route and, after listening politely to several cautionary tales, set off for the village of Pelli which we intended to use as a base for climbing a pair of neighbouring peaks. The solid wheels of oxen carts had played havoc with the track; irrigation channels (often invisible till we were in them) dissected the road; but somehow we made it. Winding and bumping through oak scrub, we arrived at Pelli as the sun sank. The local schoolmaster, forwarned by the *kaymakam* of Tuğ, befriended us and allowed us to set up our beds in the village school. Everyone crowded into the room to stare at us; *ayran* was produced, and a chicken killed for our benefit. After dark the Kurdish villagers, accompanied by the music of itinerant gypsy musicians, set about dancing. We joined in, shuffling round, bobbing up and down till our supper of chicken, rice and yogurt threatened to rebel. Oleg attempted a highland fling (much appreciated) and fell over backwards (which went down even better). We tottered off to bed, worn out, but feeling that Anglo-Turkish relationships had been put on a more human, if unconventional, footing.

The next two days were spent in climbing Pelli (Pili) Dağ that juts out into Lake Van, and an unnamed peak 10 kilometres to the south-east of it. The views were magnificent. To the east and south-east the great snowcapped ranges of Kurdistan, which we were to climb during the next few weeks, lay before us in all their glittering splendour. Below us the lake, without a sign of life upon it, basked in the hot sun.

The flora of the two peaks was rich and in full bloom; *Campanula bornmuelleri* hung out its violet bells in the highest crevices; squat chequered fritillaries bloomed by patches of snow. Although the peaks were only 10 kilometres apart, the difference between their floras was remarkable—due, perhaps, to the different aspect of the slopes we climbed. We drove on eastwards, and saw below us, unapproachable, the island of Aktamar with its Armenian church of the seventh century so miraculously carved. Skirting the north slopes of Artos Dağ, we drove across the plain to Van on the east side of the lake.

Van: what a fascination that name has held for me! And I have not been disappointed. The modern town, it is true, is an architectural misfortune, without character, without charm—but a good base for an expedition; it has a market, well-stocked shops, a dowdy hotel apparently painted with prune juice, some good restaurants offering wine and beer, and a Turkish bath. What more does a traveller need? A pressure cooker? You can buy one in Van.

The magnificence of Van lies in its situation. To appreciate this it is necessary to stay at the tiny hotel on the jetty, 7 kilometres from the town, which puts one to great inconvenience but is worth the trouble. The lines of the shore are softened by bird-haunted marshes; here you can walk in the evening and watch the ripening sun fire the surrounding peaks. To the south of the lake lies the fierce, snowy wilderness of remotest Kurdistan. To the east rises the volcanic double dome of

Erek Dağ—old Varak, which once cradled Armenian monasteries. Limestone escarpments ride the plain, more beautiful even than the hills of Attica in their perfect spacing and proportions. Across the lake to the west lies Nemrut Dağ, like the wide lap of a Buddha, and the black, vast cone of Süphan Dağ; there, according to local tradition, the Ark touched before it came to rest on Ararat.

The castle of Van encrusts a narrow limestone ridge that sails the plain like a battleship. On the south side the cliff drops sheer and bears an inscription commemorating the deeds of Xerxes, son of Darius—"like a sheet of the Times Newspaper" as an earlier traveller put it. Looking down from the castle one sees, as though from an aircraft, the ruins of old Van, unhappy memorial of those reciprocal massacres that are now part of Ottoman history. Little remains beyond the crumbling labyrinth of walls, but a few Islamic domes and minarets—all that stand—are haunted by jackdaws and owls. It is a sad, depressing place, and the new town of Van has wisely turned its back upon it. A university is planned, roads and modern agriculture push forward into the eastern provinces: progress is on the way.

We visited the governor of Van, and called on the security police. We had waited nine months for our permits, but when once permission had been granted by the Government in Ankara we found all the local authorities extremely helpful. Turkey east of the Euphrates is still a military area, and permission to travel within it—particularly if one wants to camp in the mountains—remains very difficult to obtain. On July 13 we motored south to Gevaş at the foot of Artos Dağ (3475 metres), a rather isolated mountain that stands at the south-east corner of the lake. We spent the night in the mayor's office and hired horses and guides for the three days' climb. Approaching the mountain from the west side, we lunched at a *yaylâ* (summer pasture) where Kurdish women were shaking butter in a great earthenware churn suspended by ropes. The narrow track became very steep and petered out; one of the younger horses panicked and rolled down the slope, scattering flower presses far and wide. But everything was at last put in order, and as night fell we pitched camp on the south shoulder of the peak at 3000 metres by a large snow patch. A wolf came and howled at us in the night, causing temporary pandemonium in the camp.

We set off at dawn for the summit—an easy walk over limestone slopes covered with great spiny hummocks of *Astragalus*, *Onobrychis cornuta* and *Acantholimon*; these afford protection to smaller herbs that grow through them. By patches of snow the damp soil was gay with the flowers of alpine buttercups, *Gagea*, *Myosotis* and a new prostrate blue flax related to a Greek species. Artos Dağ, like Pelli Dağ and Karz Dağ, is undoubtedly largely composed of crystalline limestone, although all this region is marked on the Turkish geological map (1/800,000) as "Palaeozoic and crystalline schist." Next day we returned to Gevaş by another route—a rough descent round the east side of the peak and down a precipitous gulley. On a windy ridge at 3000 metres a most beautiful rose-pink *Hedysarum*, with silver leaves, was in full bloom—perhaps the most beautiful alpine of which we were able to get seed. On Artos Dağ and elsewhere we saw obvious signs of Pleistocene glaciation—moraines, tarns, erratics, the valleys of extinct hanging glaciers. In Kurdistan, on nearly every *massif* over 3000 metres, we saw these traces of local glaciation. The glaciers appear not to have descended much below 2600 metres—we never saw moraines near the lake. I have seen similar evidence of glaciation in the Pontic Taurus above Rize, on Bithynian Olympus (Ulu Dağ) and in the Cilician Taurus as far west as Dedegöl Dağ west of Lake Beyşehir.

Back at Van we made a day's excursion to Erek Dağ, very desiccated at the end of July, and then drove south again to the village of Çatak south of Artos Dağ. Çatak lies on a tributary of the Tigris that is full of trout. My interpreter borrowed a blunt trident and, standing in the icy water, speared a dozen by torchlight. We were assured by the peasants that all the streams on the south side of the watershed (*i.e.* flowing into the Tigris) are full of trout, but that none is to be found in the rivers flowing into Lake Van. Çatak lies in a deep valley wooded with oaks (here chiefly *Quercus libani*) and scattered trees of *Acer*, *Sorbus*, *Rhamnus*, and *Pistacia*, In Kurdistan trees are largely confined to the slopes of sheltered valleys; only on the south-west side of the lake, between Pelli Dağ and Tatvan, is there extensive oak scrub, dominated by *Q. infectoria*, on the open hillsides—probably correlated with a higher rainfall there. Even in the valleys trees peter out by 2200 metres as we enter a wide zone of herbaceous vegetation (descending to lake level where trees are absent) dominated by several large, yellow-flowered umbellifers (*Ferula*, *Prangos*, etc.); these are pollinated by vivid beetles and look extraordinarily alike until their fruits indicate to which species they belong. It was through this zonation that we passed as we climbed Kavuşşahap Dağ (over 3500 metres) above Çatak. We camped at 2700 metres, at the top of the umbellifer zone where it gives place to the spiny hummocks of *Astragalus* that I have referred to in my account of Artos Dağ. The shepherds that summer had lost numerous sheep to wolves, and were thinking of pasturing their flocks elsewhere. Between 3000 metres and 3300 metres the *Astragalus* communities give way to a more alpine vegetation on limestone screes. Rare crucifers insinuated their diffuse rootstocks between the loose stones; a most lovely dwarf pea (*Pisum formosum*), with rose-pink flowers hovering like butterflies above the fat glaucous leaves, flowered on the most unstable slopes. By rivulets coming from the melting snow we found a more northern element in the flora: the blue enamel of *Gentiana verna* of Teesdale and the European Alps, growing with the pink *Primula auriculata* and the yellow-flowered *Primula elatior* subsp. *pallasii* (the eastern race of the oxlip).

From Van we were to set off on the journey which I had dreamt of for years: to the province of Hakkâri in the remote south-east corner of Turkish Kurdistan. Our permits being in order, we drove off in much excitement towards this Shangrila where we had every hope of finding a rich, almost unexplored flora, in magnificent surroundings. As we drove south-eastwards from Van the landscape became more desert-like and took on the unearthly reddish tones of a Salvador Dali landscape. We passed the castle of Hoşap, once a stronghold of rebel Kurds, standing immensely impressive and almost Scottish baronial on an isolated rock. A long line of camels crossed the beautiful sixteenth century bridge, banded in black and white stone like a Florentine building. The road began to rise, zigzagging up the metamorphic flank of Kepir Dağ, then down towards the village of Başkale that looks across the upper waters of the Greater Zab to the frontiers of Persia. Başkale is an armed camp, a little, dirty mountain village whose *raison d'être* is to provide a locus for a military base. We stayed there long enough to climb Ispiriz Dağ (3587 metres) that rises steeply behind the village. In the umbellifer zone of the lower slopes grew a plant, familiar enough in the garden, that I had never seen wild before: the oriental poppy (*Papaver orientalis*). How fabulous, indeed how out of place, those great, scarlet, black-centred flowers looked on the bare mountain side! On Ispiriz Dağ a wide band of serpentine rock intersects the marble that forms the summit and lower slopes of the mountain. Such petrographic contrasts have their effect on the flora. The marble summit screes, which from a distance looked empty of

vegetation, proved to be scattered with rare alpines, many of which we did not see elsewhere. The affinities of the flora were decidedly Persian.

From Başkale we drove on southwards, entering the upper part of the Zab gorge. A lorry driver coming up from Çölemerik (our destination) warned us of smugglers and bears, but we spent a quiet enough night beside the rushing torrent. The road to Çölemerik has a reputation for extremely dangerous bends and a boulder-strewn surface; and indeed we did see the skeleton of more than one lorry upside down in the river that swirled hundreds of feet below us. But the surface of the road is now greatly improved, and lorries rumble along it nearly every day during the summer, bringing supplies to Çölemerik; the village is cut off by snow for five months of the year. As one descends the gorge of the Zab—the largest tributary of the Tigris—the scenery becomes increasingly savage. The river seems to follow a fault in the rock, for the cliffs are often limestone on the east side of the gorge, and slate or schist on the west. The road passes through several tunnels, and at last emerges on to a sloping terraced shelf about 300 metres above the river. This is Çölemerik, the administrative centre of Hakkâri, a village widely scattered through fields and gardens, having no natural focus behond the administrative one where the new Government buildings, built to standard pattern with a roof of corrugated metal, dwarf the rest of Çölemerik. Except for the ruins of a pleasant khan (relic of the days when the Kurds migrated to and from the plains of 'Iraq), the place has no attractive architecture. But, built as the village is on a lip of the Zab gorge, it does have a magnificent situation. The great precipice of Sümbül Dağ frowns down on Çölemerik; yet it is inaccessable across the gorge.

The very mention of Hakkâri is enough to draw groans of commiseration from any western Turk. "The road! The people! The dirt! There is nothing to eat—take everything with you!" If such an unhappy reputation was ever justified it is not so now. The road is better than many I have been on in Turkey. Çölemerik, it is true, has no hotel and nothing that can by courtesy be called a restaurant. But everyone helps, and our stay in the province of Hakkâri was, I think, one of the most pleasant of my Turkish experiences. We had an introduction to the Director of Education and were allowed to set ourselves up in the secondary school. This suited us excellently, since it gave us plenty of room for our luggage and a certain amount of that privacy which a scientist yearns for when he is travelling in the Nearer East. The school's ping-pong table proved ideal for changing the papers in the flower presses.

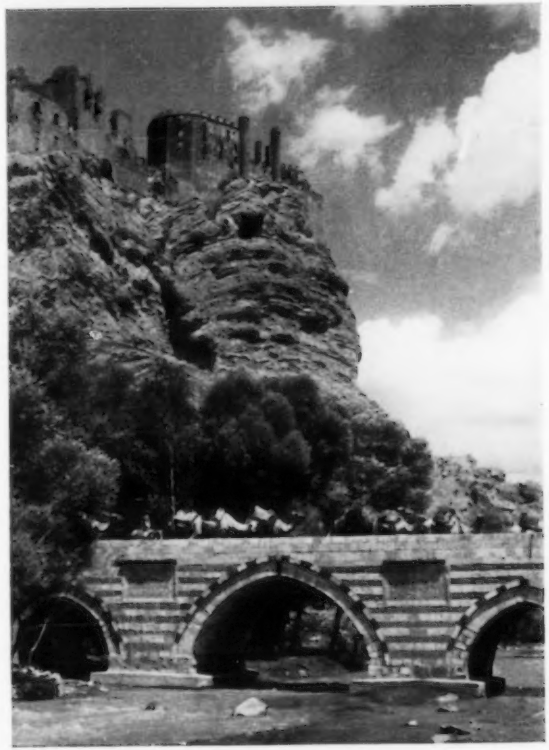
In Hakkâri we had two main objectives: Cilo Dağ and Kara Dağ, on opposite sides of the Zab gorge. We decided to tackle the more difficult Cilo *massif* first, going by the shorter, rougher route. We had been recommended to approach the mountain from Yüksekova (Gevar) on the east, but that would have taken more time than we had at our disposal. Instead, we followed the route which Earl Percy had taken in 1889.[1] Reliable Kurdish guides were chosen and sturdy horses found to carry our equipment for a week. On August 6 we forded the Zab near a police post, at its confluence with the Diz tributary. This was no easy matter, as a thunderstorm had left the river in spate. It was here nearly a hundred yards wide and flowing swiftly. The luggage was piled as high as possible on the horses' saddles and the animals driven across the river by naked Kurds who tested the river-bed with staves. We clung on as best we could and reached the other side with nothing worse than a few wet flower presses. This route can only be practicable in late summer. Earlier in the year melting snow must make it impassable; as it was, we

[1] Percy, Earl (Lord Wankworth), 'Highlands of Asiatic Turkey.' London, 1901.

Small crater lake on Nemrut Dağ

Süphan Dağ: a crater lake a 4000 m.

Artos Dağ: zone of spiny Astragalus



Castle and bridge at Hoşap

had to cross the Diz torrent several times. I should like to say a word about our Kurdish guides. We found them most reliable and glad of any opportunity to test their courage. They do much to make travel in Kurdistan much easier than it would otherwise be. Travelling in parts of the Cilician Taurus and Anti-Taurus is much more difficult because of the trouble one has in those regions in finding reliable guides and sufficient pack animals.

We followed the Diz valley right into the heart of the Cilo *massif*. Abandoned Nestorian churches stood perched on the valley sides. Here, as elsewhere in the provinces of Van and Hakkâri, we saw traces of old terraces, vines and figs run wild. Until the present century and the final exodus of the Nestorians, Hakkâri must have been relatively prosperous. But agriculture has been almost abandoned, the Kurd being more interested in his flocks than in the refinement of cultivation. This lack of interest in the land is one of the most difficult problems that modern Turkish governments have had to face in eastern Anatolia. It was in the gorge of the Diz valley that we made one of our most exciting botanical discoveries: a new species of *Primula*. It grew in crevices of apparently dolomitic limestone, and was in seed at the time of our visit. It has grown well and already flowered at the Royal Botanic Garden, Edinburgh: a very dwarf species with deep yellow flowers. Crab apples grew in the gorge (descended, perhaps, from Nestorian orchards), and we saw where their branches had been torn down by the bears that were very numerous here. We had lunch beneath a rock where, the Kurds assured us, a shepherd had been mauled to death a month before. When a bear had carried off one of the lambs, the shepherd had stoned the beast—with the not unexpected result. There is a widespread belief in Hakkâri that white bears exist in the Cilo Dağ—white all the year round. However, it must be admitted that the Kurds are singularly prone to shaggy bear stories, especially ones about bears carrying off young brides. The bear is no doubt a convenient scapegoat for an occasional abduction.

We left the Diz valley near the hamlet of Sua (Suga?), and climbed steeply to Cilo *yaylâ* below the magnificent pyramid of Cilo Tepe (about 4100 metres). Here we pitched camp for three days at 3000 metres, thanks to our guides on excellent terms with the Kurds who were encamped there for the summer. The scenery here is the most magnificent in Turkey, resembling nothing so much as the Dolomites. The great limestone cliffs (marked on the map as of Eocene age) are banded by dark volcanic intrusions. Even in mid-August snowfields are extensive. A small living glacier was recently described by a Turkish geographer as flowing from the north side of Reşko Tepe (4168 metres, the highest peak in the massif), but unfortunately we did not have time to reach it.[1] Barren though this splendid *massif* looks, it has a rich flora that is very different from the rest of Turkish Kurdistan. We collected 400 species in less than a week, and there is no doubt that a considerable number of these are new to science.

From the pass over Cilo Tepe we looked across to the mountains of Oramar and towards Şemdinli that at once became, now that we had at last reached Hakkâri, the botanist's ultimate goal; but that will have to wait for another year. We descended once more into the Diz valley where my guide sprained his ankle. "I cannot move," he groaned. "Night is coming on. The bears will get us." "Oh, no they won't!" I said, and coaxed, pulled, bullied and bribed the poor man till I got him down the ravine to rejoin the rest of the party who had wisely followed the path. By the time we reached the Zab the flood water had somewhat

[1] Izbirak, Reşat. 'Cilo Dağı ve Hakkâri ile Vangölü çevresinde coğrafya araştirmalari. Ankara, 1951.

subsided and we were able to get back to Çölemerik with a wonderful collection of plants.

Before climbing Kara Dağ north-west of Çölemerik, Oleg Polunin paid a visit to the Nestorian church at ruined Koçanis. It stands on a tongue of land falling precipitously to ravines on either side, and is far superior to the little churches we had seen scattered in the Cilo Dağ. Koçanis was once the headquarters of the Nestorian patriarchs. In the sixth century the power of the Nestorian Church extended from Jerusalem to China. In the fourteenth it was the largest communion in Christendom, outnumbering both the Greek and the Roman Churches. Then it collapsed. Persecuted by Tamurlane, its patriarch and surviving followers were pushed back into this wild corner of Kurdistan. In 1890 the famous Patriarch Mar Shimum was visited by the indomitable Isabella Bird (Mrs. Bishop—the first woman Fellow of the R.G.S.). She has given the most fascinating account of Koçanis in its decline, its inhabitants raided and persecuted by the turbulent Kurds.[1] Now no Nestorians (apart from a few converted to Islam) remain in Turkey, though the sect survives over the frontier in 'Iraq and has outposts elsewhere. Many of the beautiful striped clothes worn by the Kurds are woven by Nestorians in 'Iraq. Even the sign of the Cross persists, woven into woolly Kurdish socks, its significance forgotten or ignored.

From Çölemerik a rough road to Van (via Gürpinar) passes over the east flank of Kara Dağ; until recently this road was open for about a fortnight each year, in late August or September, when the snow melts away on the 3000-metre passes. But at the time of our visit snow still blocked the road, and the authorities of Hakkâri and Van had not collaborated to clear it; with the road through the Zab gorge so much improved, there is little incentive to maintain the higher, more direct route to Van. We drove as far as we could, and camped at the *yaylâ* of Sheikh Selim Bey. The *Ağa* is the spiritual leader of the Kurds in this district of Turkey, and a most remarkable, wise and influential old gentleman. He was very animated, with a white, well-combed beard and bird-like eyes that were never still. Guests were always coming and going, and we spent a most interesting day, reclining on carpets and cushions, and eating an endless and rather mysterious meal, like an oriental Burns supper, washed down with innumerable glasses of sweet tea. The glasses were perpetually refilled until we laid them on their sides. Kara Dağ has a geology that differs considerably from that of the mainly calcareous Cilo *massif*. Its lower slopes (bristling with species of *Echinops*, *Cirsium* and *Eryngium*) consist of a greenish metamorphic rock (chloritic schist?), but the summit is undoubtedly granite—over 200 kilometres from the nearest outcrop (Toraman Dağ, north-west of Lake Van) marked on the Turkish geological map (1/800,000). There can be no doubt that this region of Turkey would be a wonderful place for geological research. Evidence of Pleistocene glaciation, well-marked on Cilo Dağ, was even more noticeable on Kara Dağ. Although late in the season (August 16) there were streams and flushes that supported a decidedly northern element in the alpine flora —gentians, primulas, moonwort, even a sedge that in Britain is confined to Ben Lawers (*Carex microglochin*). The botanical interest of Kurdistan owes much to this meeting of northern and southern floras. The phenomenon is related to the climatic changes of the Pleistocene and the varied ecological niches which the area provides for survival.

We returned to Van by way of the Zab gorge. By the lake the corn had been cut, and threshing and winnowing were in full swing. Bullocks, pulling sledges bearing

[1] Bird, I., 'Journeys in Persia and Kurdistan,' vol. 2. London, 1891.

Crossing the Zab above Çölemerik

Zab gorge at Hakkâri

Sheikh Selim Bey's encampment on Kara Dağ, Hakkâri

Sheikh Selim Bey, in white turban, Kara Dağ, Hakkâri

revolving blades, plodded round and round, threshing out the grain. Clouds of golden chaff rose in the air, tossed up by the wide winnowing forks. The whole landscape was a glorious symphony of muted yellows and old ivory, hill and plain bleached by months of sun; the snow had left all but the highest summits of Kurdistan. Only one major peak remained to be climbed: Süphan Dağ. With some difficulty we got our Land Rover on board the steamer, crammed with soldiers and gaily dressed Kurdish peasants, and sailed uneventfully to Tuğ.

We gathered seeds in the neighbourhood, climbed Karz Dağ for the second time, and then drove off round the west shore of the lake. We passed the thirteenth century Seljuk mausolea of Ahlat, built out of a rather unpleasant reddish lava, their conical roofs clearly "inspired" by Armenian churches. Most of these mausolea have none of the grace of the best Seljuk buildings in Konya, Karaman or Niğde. The Seljuk tombs of Ahlat are well known, but one hears little about the great moslem cemetery of the same period where thousands of gracefully carved headstones, leaning this way and that, cover the plateau for a vast area; they were, we thought, far more beautiful than those rather oppressive tombs. We drove on, ploughing over tracks several inches deep in volcanic dust, and reached the village of Adilcevaz near the foot of Süphan Dağ. We found an inn, and visited the most helpful *kaymakam* who arranged for horses to meet us next morning at the village of Nurşencik. The sun was rising when we drove into the little village, a cluster of low, mud-brick houses interspersed with cones of dried dung blocks. These dung cones are a characteristic feature of the plateau landscape, and, in the absence of wood, provide the villagers with fuel. As very little manure gets on to the land, crops are poor. The Government is doing its best to improve matters by sending artificial fertilizers to the eastern provinces.

Although the second highest peak in Turkey, Süphan Dağ is nevertheless one of those mountains that are better seen from a distance. All day we zigzagged our way up black dusty slopes covered with a mass of fruiting umbellifers, thorny *Astragali* and savage thistles—not a tree or shrub to be seen. Water was scarce, as it always is on these volcanic mountains of inner Anatolia. Towards evening we reached the broken rim of the crater and pitched our tents at nearly 4000 metres by a little lake. Blocks of ice floated in the water, and a glittering ice face clung to the shaded wall of the crater. At night the lake froze over. Despite its greater height, the mountain obviously gets much less snow than the main block of Kurdish peaks to the south-east. On August 26, climbing laboriously up the great lava blocks as though we climbed an endless pyramid of Cheops, we reached the top. The summit (4434 metres) consists of an eruptive mass of lava that has risen on the earlier rim of the crater and appears to have blown part of the latter away. A score of alpine plants had secured a foothold at the top, and we came upon a dead hedgehog—dropped, an ingenious Turk suggested, by one of the Lammergeyers that hopefully circled the peak. The view was worth the climb. To the south all the ranges of Kurdistan, as far as the Cilo Dağ, could be seen beyond the lake. To the north-west lay the pallid plateau, shimmering in the heat, and beyond, without a cloud upon it, the highest mountain in Turkey 150 kilometres away: forbidden Ararat, its great 5156-metre cone white with perpetual snow. We returned to the lake and got ready to make for home. Nearly three thousand gatherings of pressed plants (in quintuplicate) were packed away in crates, a most satisfactory haul from a part of Turkey whose plant life was almost unrepresented in British herbaria. Then we drove to the Black Sea, its forest dark with rain, and on to the fleshpots of Istanbul. The quail had arrived before us.

DISCUSSION

Evening Meeting, 28 March 1955

Before the paper the PRESIDENT (General Sir JAMES MARSHALL-CORNWALL) said: Lake Van is an interesting lake geographically, being about 80 miles in length and about 40 miles wide, situated 5700 feet above sea level in south-eastern Turkey. It is in the old homeland of the Armenian people, the centre of a debatable land which has been fought over for many centuries, between the Roman Legions and the Parthians and later between the Byzantine Empire and the Seljuk and Ottoman Turks. Kurdistan runs right across Lake Van and is really a geographical and not a political term, which covers south-eastern Turkey, northern 'Iraq and part of north-western Persia. It is mountainous country, inhabited by intractable people who have been independent warriors since the time when Xenophon's Ten Thousand, returning from their Anabasis, came across the Carduchi, and they have been a political problem for many centuries past. It is difficult nowadays to get access to the area, and I believe Dr. Davis had nine months' hard work before he obtained permission to go to Kurdistan. He is a Lecturer in Botany at Edinburgh University, and specializes in the flora of Turkey and the Middle East.

Dr. Davis then read his paper

The PRESIDENT: We are greatly indebted to Dr. Davis for having pictured to us so graphically the physical geography and the flora of that wonderful country, Kurdistan, in which we cannot easily travel. We have with us this evening Lord Kinross, who has also visited that particularly fascinating country. Probably most of those present have read his book describing his travels, 'Within the Taurus.' He travelled over part of the country, not in search of flowers, but to find out what the people were doing and thinking about. He has the happy facility of being able to go into the vilage "local" and get to know what the "regulars" are thinking and feeling.

Lord KINROSS: I once had the opportunity to travel with Dr. Davis in the highlands of southern Turkey, but the discomfort and rigours of travelling with a professional botanist as conscientious as he is were beyond me. While I thankfully rode a mule, he would walk for about eight or ten hours and then, when we stopped at night to camp and I lay down to rest, he spent another four or five hours pressing his flowers, far into the night. The journey I have mentioned was done in a part of Turkey easy to visit; no permits were required. For the eastern *vilayets* it is still necessary to obtain permits; indeed, without a permit one may get into trouble.

But there is no country which is more hospitable and kind, provided the traveller has the right permit. I wish I could have been able to visit Kurdistan to the same extent as Dr. Davis has. It is a most interesting country and, in a sense, the Scotland of Turkey, the Scotland of perhaps twenty or thirty years after the Rebellion of 1745; that is to say, these wild highland people are slowly but gradually being absorbed by the Turks, or perhaps they would say they are gradually absorbing the Turks. It is a country completely calm, vigorous and independent, which still preserves its own traditions and way of life. It is an enormous measure of the changed attitude of the Turks that they allowed Dr. Davis to travel in the country, that they now allow expeditions of reputable people to visit Kurdistan. This new attitude towards the foreigner has been developing since the end of the last war. The Turks are now anxious to do all they can to help the foreigner, so that we now seem in a position to get back to the days of the nineteenth century when there was a very friendly feeling towards an English traveller in Turkey. In those days numerous travellers, botanists and scientists were given the opportunity to travel freely around Asia Minor, and many interesting books were written about that area during that particular period. It looks as though a new era is starting in which it is becoming possible to re-establish that tradition of travel which is one of the finest and oldest traditions of the Royal Geographical Society.

TRENDS IN THE GEOGRAPHICAL PATTERN OF DISEASE

A. LESLIE BANKS

I WOULD LIKE first to say how deeply I appreciate the privilege of the invitation to give this lecture. I have had during the past six years many happy associations with the Department of Geography at Cambridge, and members of that Department, and particularly Professor Steers, have given me much encouragement. When I was appointed to the chair in Human Ecology in 1949 I realized that such contributions as I could make to our knowledge of the relationship of man to his environment depended to a considerable extent on the help which I received from other departments and faculties working in this field, for no man could hope to make himself a complete authority on this complex subject. I have therefore endeavoured always to remain close to my own base-line of the social aspects of disease, and it is with this special interest in mind that I speak today. Geographers are, by definition, interested in the earth as a whole, and it seemed to me that I could most usefully repay your kind invitation by attempting to portray the general pattern of disease throughout the world, with particular reference to future trends. Such a wide approach must, of necessity, be superficial, for a detailed study of the effects of even one disease, *e.g.* malaria, would require a number of lectures, and a degree of specialized knowledge, both on your part and mine, which we do not possess, for no one has, as yet, all the facts.

It is over 200 years since Swift wrote:

> So geographers, in Afric maps,
> With savage pictures fill their gaps,
> And o'er unhabitable downs
> Place elephants for want of towns.

Even so, no one today would claim that our knowledge is complete, and particularly of Africa. It is the same with medicine. There have been many advances in recent years, and we have acquired powerful weapons for the prevention, diagnosis and treatment of disease, but our knowledge of the long-range results of our efforts is indeed inadequate. It is becoming apparent that there is an urgent need for co-ordination of the various disciplines concerned with man and his activities, and in this connection the association of medicine with geography offers a most promising field.

The nature of man.—When one surveys the health and welfare of mankind in highly industrialized communities one is immediately struck by two things. Firstly a great increase in the number of people living to mature adult life, and secondly the fact that the principal cause of death is now some disaster of the cardiovascular system, either of the arteries supplying the heart or the brain. The reasons for the increased expectation of life from birth are sufficiently well known, and may be summed up under the headings of improvements in the environment, better housing, education, and especially success in our efforts to control the killing diseases of infancy, childhood and adolescence. The second fact is less easy to explain, but if we are to attempt to do so then I think we must go back in time. Prehistoric man, like the hominids who preceded him, developed a bodily mechan-

ism which, anatomically and physiologically, was adapted to suit the life he led. Thus it was designed for immediate fight or flight as the occasion might demand; his digestive system was accustomed to his peculiar food, and his heart and arteries were suitable for his short intensive life. His relatively simple mental processes sufficed for a situation where his actions were largely reflex, and he, like primitive man today, had an uninhibited reproductive system.

The main difference between those people and ourselves would, I think, be found in the development of the central nervous system, and particularly the increasing degree of control which the forebrain now exerts over the rest of the body. The development of memory, intelligence and foresight, has enabled man so to triumph over his environment that in certain communities he is no longer compelled to exert himself physically, and his struggle for existence bears no resemblance to that of his forebears. He need not run, he need not walk, he need neither go to sleep at sundown, nor rise early in the morning. For much of his time he sits inert at a desk, or stands before a machine. Even his hours of recreation may be spent passively, in sitting and gazing at screens of different kinds. On the other hand such a man is subjected to mental stresses quite different from those requiring the instant reflex action of the animal world. He has now to consider events as they may happen next week, next year, or indeed half a lifetime hence, and his antennae bring to him knowledge of crises all over the world in addition to those of his daily life, so that he is constantly having to make, consciously or subconsciously, a selection from these many events in shaping his own course of action, and that of his family. In spite of this he has, as yet, only incomplete control over the rest of his body, the mechanism of which he has inherited from the long distant past. It is dangerously easy to generalize, but the primary motive forces of the animal world, of which he forms part, are survival of the individual and reproduction of the species, and man now imposes rigid controls over his instincts in both these fields, for he subjugates his natural impulse to run away or fight it out, and he limits very considerably his sexual activities as compared, for example, with truly primitive societies. All these factors must be borne in mind when considering diseases in which mental and emotional stress plays a part, for they help to explain not only increases in the number of deaths from coronary thrombosis, and cerebrovascular disease, but also the increasing amount of minor mental ill-health which is to be found in the highly industrialized communities of the world.

I hope to discuss the stresses of modern civilization further, but I would here point out that the blocking of a small branch of a coronary artery supplying the heart in a world statesman, or the maniacal emotional outbursts of a dictator, depend, in essence, on these ancient bodily mechanisms.

The pattern of disease.—The pattern of disease throughout the world is older than man himself, and some of the great killing diseases known to us have left their mark on skeletons of prehistoric animals and Egyptian mummies, while the earliest written records show knowledge of disease prevalent today. Indeed, some of the remedies recorded in the earliest papyri are still in use. As man spread over the face of the earth he carried with him diseases which were already well established, and particularly the great infections. Speaking very generally, it is possible to recognize in ancient as in modern times diseases which spread directly from man to man, in addition to those conveyed by insects or other vectors. Then, as now, accidents and the wear and tear diseases, diseases due to malnutrition, and those caused by new growths, were to be found.

All these were prevalent in ancient times, but the pattern became recognizable

on a world-wide scale (save for variations due to climate) only by early medieval times, when an Arab or Persian physician could have practised his art successfully in any European city. War, pestilence and famine, all helped to make the picture a universal one. There were the great epidemics inseparable from mass movements of people, there were the diseases associated with starvation and overcrowding, and above all there were the results of ignorance, poverty and neglect. For these reasons the overall picture in medieval times was that of high death rates in infancy and childhood, many diseased adults, and few old people, for the average expectation of life from birth rarely exceeded nineteen years. The killing diseases were recognizably similar throughout the world, for the conditions which we would today associate with tropical and sub-tropical areas, such as malaria, cholera, parasitic infestations, trachoma, leprosy and plague, together with dysentery, were all to be found in Europe, and indeed in Britain. It is not surprising, therefore, to find that the so-called temperate climate diseases still have great significance in the tropics, and in particular pneumonia, tuberculosis and the venereal diseases.

We are on common ground when we stress the importance of the environment on human health and well-being, and subdivide it into physical, biological and social. Where we are less sure of ourselves and, indeed, almost completely in ignorance, is in attempting to assess the part played by heredity in predisposing to disease or ensuring immunity from it. In the present state of our knowledge I think that we can best concentrate on environmental factors, and leave the long-term genetical implications until more is known about them. The environment, indeed, offers quite enough problems. If we consider for a moment the physical environment we find that man has always been his own worst enemy in making conditions ideal for the spread of disease, by polluting water, food and air. Even his attempts to protect himself against extremes of climate by means of housing have led him to the evils of overcrowding, whether in the *yurts* of the nomads of Central Asia, the *igloos* of the Eskimos, or the slums of cities.

I will not bore you by reciting a catalogue of the diseases which may result from a faulty physical environment, but merely draw your attention to one example. One would have imagined that all that could be said about water and disease had in fact been told, but that is not the case. Not only have we converted our rivers and streams in this and other countries into open sewers, but we add almost daily to the complexity of the industrial waste products which we pour into them, and we are now about to add to these still further by way of radio-active substances. An eminent American authority has recently said that in fifty years' time the volume of fission products requiring disposal each day throughout the world will be so great that one-twentieth of the volume of the oceans of the world would be required for dilution of these wastes. (Wolman, A., and Gorman, A. E., American Society of Mechanical Engineers, Paper No. 54-A-72 1955.)

The emergence of two worlds.—The general picture of disease began to change in Europe about three hundred years ago, when the voyages of discovery, together with the growth of industrialization, led to a rise in social standards and improvements in nutrition. This was particularly well seen in England, where the last great epidemic of plague occurred in 1665. The reasons for its disappearance have never been clearly understood, but it is probable that the Great Fire of London in the following year swept away many of the harbourages for rats, and throughout the country such amenities as the substitution of carpets and rugs for the older rush coverings of the floors had similar results. There was also a general rise in the standard of living, and it became evident that in Europe, and later in North

America, these improvements were having their effects on the ancient pattern of disease.

By the end of the seventeenth century men in France, the Low Countries, and England, were consciously turning their attention to the possibility of preventing disease, and we have the Dutch mathematicians, John Graunt in London who found that "36 per centum of all quick conceptions died before six years old," Sir William Petty, and others, attempting to estimate in terms of economics the possible losses caused by disease, and to forecast the average expectation of life. In the next century the pace of scientific discovery, and the application of scientific inventions, was speeded up, and by the end of the eighteenth century we find attention being turned here and there to the possibility of organizing medical services in such a way that the State would assume responsibility for the protection of the public health. A good example of this was Frank's "polizeimedizin."

Then came the growth of industrialization on a massive scale, with all its benefits and disadvantages, for although the diseases due to defective physical environment were gradually brought under control, those due to a faulty biological and social environment increased. While our forefathers were endeavouring to secure pure and adequate water supplies, and freedom from contamination of food, there was at the same time developing gross overcrowding in the slums with all its dangers. Faulty industrial and working conditions, long hours of employment, fatigue, casual labour, drunkenness, ignorance and brutality, all played their part in establishing a new and more vicious pattern of disease than the earlier one. Industrial accidents and poisoning, the common infections, and above all tuberculosis, made life in England a brief and uncertain thing in the first half of the last century. Little more than a hundred years ago, for example, the expectation of life from birth of a gentleman or professional man in London did not exceed forty-four years, that of an artisan twenty-four years, and of an unskilled labourer even less. In the year 1853 37 per cent. of all deaths in England and Wales were due to infection, whereas in 1953 only 4 per cent. were so caused, and of these one-half were due to tuberculosis, one-seventh were due to syphilis, and only 1·7 per cent. due to the acute infectious diseases. It can be said that in 1853 disease and early death was the normal picture, whereas today it is highly abnormal. It should be remembered that many of the infectious diseases of the air passages and lungs are spread by means of droplets and infected dust. Also, when human beings are "styed together," to use the picturesque language of the Victorian reformers, then their habits of life approximate to those of animals similarly placed.

Overcrowding may be found in rural as well as urban societies, but agricultural communities are spared at least one menace of industrialization, and that is the combination of smoke and fog. The number of lives that have been prematurely lost, and the distress caused by chronic respiratory disease, such as bronchitis, in industrial cities, is almost incalculable. Nor is that the full story, for it seems clear that cancer of the lung depends, in part at least, on pollution of the air for its increased incidence.

It is only within the past few years that we have begun to shake off the combined effects of the ancient pattern of disease and the aggravation of this produced by industrialization. In general, the picture for western countries today is that of communities with a relatively low birth rate, a low infant mortality, healthy children and adults, and many old people. The principal causes of death in such countries are no longer the infectious diseases of early infancy, but the degenerative diseases of the heart and blood vessels to be found in later middle life, with cancer a close

second. Similarly, when we come to examine the principal causes of illness in such countries we find that they include conditions in which stress plays a considerable part, together with much minor mental ill-health. There is also a high accident rate on the roads, in the home, and in the factory. In passing, it is not generally realized that accidents in the home cause more deaths (about 6000 a year in England and Wales) than those on the road. This figure takes no account, of course, of the resulting disability in those who do not die.

On the other hand we have well-organized health and welfare services, stable local and central government, and, most important, a high level of nutrition. In a nutshell, then, we in western countries are moving into an era where the principal causes of death are those of later life, the principal causes of illness are mental rather than physical, and we are forming a society with an increasing number of elderly people in it. Meanwhile the pattern of disease in the rest of the world had until recent years remained relatively unchanged.

The so-called backward areas of the world.—It is important to remember that it is only a short time since we in the western countries were as backward, from the disease point of view, as those now to be described. The last cholera epidemic occurred in England less than ninety years ago; ague (or malaria) was still to be found in the eastern Fens fifty years ago, and the infant mortality rate in London in the year 1900 was as high as it is in many eastern countries today. Broadly speaking, however, the ancient pattern persisted almost unchanged in many of the countries of the world. In these could be found the killing diseases of temperate climates, in addition to those resulting from the adverse environment. Thus malaria, pneumonia, tuberculosis, and syphilis, the water-borne infections, typhoid, dysentery, and cholera, and dust and insect-borne diseases, combined with the parasitic infestations to cause untold misery. It is not generally appreciated to what extent worms and other infestations can handicap the human race. In addition to the common round-worms, thread-worms and tape-worms, there are blood flukes, liver flukes and lung flukes, while the hook-worm (*ankylostoma*) and the cause of bilharzia, a schistosome, may number their victims in millions. N. R. Stoll, writing of "This wormy world" in the *Journal of Parasitology* in 1947, estimated that 114,000,000 people throughout the world suffered from the effects of bilharziasis, with all its disadvantages of ill-health, weakness and lethargy. Similarly with hook-worm; this disease, extending as it does from 36° north of the equator to 30° south, can affect one-half of the total inhabitants of the world.

The natives of many of these countries, and particularly those in the humid tropics, are also susceptible to fungus infections, and, above all, to the diseases due to malignant malnutrition, of which kwashiorkor in Africa is one example. In this condition protein deficiency in the diet is associated with a relatively high carbohydrate content. The results of giving protein supplements, for example skimmed-milk powder, to such children may be quite dramatic. In these countries also it is not unusual to find a combination of five or six different conditions in the same person, as compared with one disease to be found in our own and similar communities. Some of the results are immediately obvious. Infant mortality rates are high. Indeed it is still possible to find communities in parts of the world where only one in two children can expect to survive to adult life. The proportion of adults suffering from disease is a high one, and the expectation of life is very short, especially for women.

Until recently these conditions were of little concern to other parts of the world, except for common feelings of humanity, and a fear of world-wide epidemics of

disease. Even today it comes as a shock to read the opinion of such an eminent authority as Dr. Jacques M. May, writing in the *American Journal of Tropical Medicine and Hygiene* in 1954 (vol. 3, No. 3), "It can be summed up thus: from the waters the people get their food, also their cholera, their dysentery, their typhoid fevers, their malaria; from the earth they get their hook-worm; from the crowded villages they get their tuberculosis and their yaws; from the type of housing they have been forced to adopt they get their plague and typhus; and from the food which earth, temperature, and rain produce, their protein deficiencies, their beri beri." I mentioned just now that our interest in such countries was mainly confined to the diseases which might come from them and inflict themselves upon us. Thus the East has traditionally been the source of epidemics of smallpox, cholera, and plague, and more recently of influenza. When these infections could travel only at a slow pace it was of small concern to the sophisticated European that millions of his fellow human beings might be dying of these conditions, for there was little he could do to help them. Only when the disease threatened his own shores did he begin to get seriously alarmed. Today the picture is altogether different, for there have been many changes as a result of the world-shaking events of the present century.

The past fifteen years.—Between the First and Second World Wars there was a rapid opening up of world communications, especially by air. There were also many new medical discoveries, the antibiotics, the sulphonamides, and the new insecticides, D.D.T. and the like. There also arose the possibility of mass immunization against many diseases hitherto regarded as uncontrollable. After the Second World War there was a great expansion of interest on the part of the western countries in the rest of the world. This arose partly because of altruism, partly through fear, and partly by reason of increased economic needs. One result was the development of international teams, capable of moving into a country to attack disease on a massive scale. Thus it was found possible to attack the mosquito in such a way as to stamp out malaria within a few months. In Ceylon, for example, in the year 1947 the death rate per thousand fell from 22 to 14, as a result of the anti-malaria measures. Tuberculosis could be counteracted by means of vaccination with B.C.G., and diseases like syphilis, bejel, and yaws were found to be readily susceptible to treatment with the antibiotic substances. Smallpox is now under control, and so also is diphtheria.

In addition to this international action all countries are now making efforts on a national scale to improve the health and welfare of their members, and the awakening of voluntary effort is also not to be despised. Above all, regard must be paid to the demands of the women for improvement, for they are now asking not only for maternity and child welfare services but also for better health services in general, and pure and adequate water supplies in particular. It is indeed difficult to exaggerate the importance of water in connection with health. It is already possible, therefore, to see a change in the pattern of disease in many of these countries and there is now a dangerous disturbance of the existing biological balance, for we may see persistently high birth rates together with a marked decline in infant deaths, so that many more people survive to adult life, and the problem of population pressures in search of food becomes acute.

The future.—It is only a question of time before it becomes one world again from the medical point of view. It may take 30, 50 or possibly 100 years, but I do not think it will be much more. I do not mean to imply by this that there will be a uniform pattern of disease, for that would take no account of variations of climate

and the like, but I believe that the means of controlling disease, and knowledge of the ways of promoting health, will be universally applied. If and when that comes to pass we shall again be thrown back on man's elementary requirements. Some of these are obvious. He will need, as he has always needed, adequate food supplies, pure water supplies, shelter from the elements, and good health, but for vastly increased numbers. We are therefore leaving behind us the time when disease and disease control was a matter solely for the medical profession, for the current problems are no longer primarily medical but social. An important factor in the production of disease, for example, whether in the East or the West, is bad housing, and particularly overcrowding per room. The latter predisposes to the spread of droplet-borne infections, including many virus infections such as the common cold, influenza and measles, and also to the great respiratory infections, and especially tuberculosis. There is a pressing need to study the type of house most suitable for a given country and to produce this at an economic cost.

It is, therefore, in changes in the social environment that the most hopeful prospects may be found. It has taken us nearly 300 years to realize the importance of planned development of towns and cities, with due attention to green belts, facilities for recreation and the like, and it is now coming to be recognized that in the agricultural areas of the world similar attention must be paid to developments at village level. Egypt has played an important part in demonstrating the value of community development schemes such as that at Sirs el Laiyana, in the Minufiya area. Here, under a social worker with a basic training in agriculture, have been developed simple clinic facilities, staffed with doctor, midwife, and sanitarian. Similar developments may be found elsewhere in the Middle East, often with a school attached. Their value, from the health and educative points of view, is inestimable. Meanwhile we have got to recognize that our knowledge of the true facts, as measured by statistics, whether they be medical, geographical, demographic or economic, is slender. Even if all the answers were known at this moment the application of that knowledge would often rest on political factors outside our control. One positive advantage of such a situation is that we can, without harm to our consciences, decide to conduct further research. The title, or umbrella, under which such research might be prosecuted is of little moment. For, whether it is called biogeography, geomedicine, human biology or human ecology, the basic principle remains the same—namely, a joint effort. I would like to see a research project set up whereby the physical characteristics of an area might be studied in an orderly sequence, including past history, climate, water supplies and other natural resources, together with the customs and habits of the people, and their reactions to disease and its control. With such a comprehensive assessment we should be in a strong position to make recommendations for a balanced future development. Equally important, we should have learnt the technique of working together.

It is clear, therefore, that there is a vitally important part to be played by geographers. I have learned from Professor Steers, for example, of your desire for long-term hydrological studies. It has occurred to me that you might usefully project your studies into the past as well as being concerned with the present and future. Why, for instance, have certain countries, ports or territories, such as Herakleia in the lower Meander Valley, known to be prosperous and fertile in ancient times, been abandoned? If it was because of malaria, or some other disease which we can now control, then surely such territories might be brought into use again. It seems to me that here is a really worthwhile field of investigation in which

your profession and mine could take part, to our mutual benefit and that of mankind in general. The geographer relies extensively on maps in his study of world conditions, and here also there is a useful field for joint exploration. Attempts to portray the world-wide incidence of disease have been made, notably by Rodenwaldt in Germany and Jacques May in New York with the American Geographical Society, but such efforts have unavoidable limitations, not least being the inaccuracy of vital statistics in many parts of the world. We already know much about the basic factors underlying the prevalence of disease, even in the so-called backward areas of the world. Such matters as local density of population, the state of nutrition, and of health, and the standards of living, are all of importance and can be depicted. In tropical areas, particularly, it is now clear that the maintenance of health is dependent on a number of factors, and especially the standard of living. Until this is raised above a certain level, and kept there, short-term measures to control any given disease, however successful immediately, will be of little avail in the long run. The mere raising of living standards, on the other hand, will, as our own history has shown, assist in reducing the incidence of disease. For it is not one but many conditions which handicap the native peoples of many parts of the world. The Arab farmer, for example, if freed from his parasitic infestations and other infections could, it is said, do in three hours what it now takes him ten to do.

In this the geographer has, it seems to me, most important work to do. It is for him to determine what the country was formerly like, what its maximum potentials are now, and what these could be raised to in the future. Such enquiries are, I think, more likely to be profitable than, for example, a search for a universally applicable contraceptive. There is also an urgent need for teaching. One of the greatest demands of the world at the present time is for leaders with a sense of responsibility and integrity, and I have thought for some time that such men are best taught by the people who can show why high standards are necessary. Geographers are particularly well qualified to teach the need for knowledge of, and leadership in, the development of the natural and human resources of a country or community.

A matter which is becoming increasingly clear is the need to relate the interests of the individual to those of society as a whole. It is now reasonably well established, for example, that there is a relationship between the amount of fluorine in a water supply and the extent of dental caries in the community. It would appear, therefore, to be a simple matter to add fluorine to water where this is necessary but, as recent correspondence in the press has shown, such action on the part of the community may arouse quite strong resentment as an interference with the liberty of the subject. Articulate, that is to say literate, communities can discuss such matters freely, but the illiterate cannot, and one has seen some very unfortunate results of "progress" whereby newly constructed irrigation canals have become infested with the water-snail carrying bilharzia, so that the people were leaving this potentially prosperous area for a more healthy one. The need to coordinate the activities of those developing a country, and to take into account the level of intelligence, customs, and habits of the people, is of the utmost importance. This seems to me to be a vital part for geographers to play, and especially those whose responsibility it is to teach.

In conclusion, man has been on the earth quite a long time now, and has shown that his power of survival is great. That is, in the nature of things, particularly evident to my own profession, and the medieval surgeon Ambroise Paré was

accustomed to say of his successful cures, "I dressed him, God healed him." We are, in fact, dealing with what Carlyle called the most plastic of creatures, and one with an inherent power of recovery from disaster. It has become almost a cliché with me to end this type of lecture with the old Latin tag of *festina lente*. On this occasion I propose to follow the example of another and greater scholar, for it was Francis Bacon who said "It were good, therefore, that men in their innovations would follow the example of time itself, which indeed innovateth greatly, but quietly, and by degrees scarce to be perceived."

THE ORIENTATION OF DUNES IN BRITAIN AND DENMARK IN RELATION TO WIND

S. Y. LANDSBERG

THE PROBLEM of dune orientation in this country has received little attention, and since there are few British published accounts of dune morphology, it is perhaps relevant to outline first of all the major dune types found in Britain and Denmark, before their orientation is discussed.

There are two main types. First, those which develop singly, or in parallel rows, parallel also to the coastline, as for instance, at Southport (Fig. 6) or in Aberdeenshire (Fig. 4b, c). They are usually not more than a few feet high and several yards apart, and it is to these that botanical workers have related primary vegetation series. Their orientation does not result primarily from the action of wind, and their disposition is consequently not further discussed here.

Dunes of the second type develop as masses whose orientation cannot usually be correlated with the coastline, though occasionally, as at Braunton Burrows, it may coincide. In some regions the long axis of the major sand masses appears to be parallel to the "prevailing wind," for instance at the Sands of Barry (Fig. 5), and Burghead Bay (Fig. 3); in others apparently at right-angles as at Forvie (Fig. 4a). In many areas a confused pattern may develop—the *aufgelösten Dünenlandschaft* of continental workers—where no markedly elongated axis is obvious, *e.g.* Southport or Hansted dunes (Fig. 10a). All these dunes, for our purpose, can be considered as variations of the U-dune type, on scales ranging from several yards to several hundred yards, and which may occur singly, or in laterally connected bands, or may overlap neighbouring dunes. They may also pass through various stages in a repeated cycle of mobility, stability and erosion.

In the first phase (Fig. 1, phase 1) the U shape may be hardly visible in the field, the dune having smooth curves, very short or absent upwind arms, and no vegetation, or only sparse marram. When moving relatively fast, the leeward slope may be a slip face [1] and in this respect resembles the desert barchan. Under desert conditions, however, the wind along the base of the dune is unimpeded. The diversion of the oncoming sand round the lower flanks concentrates its stream and tends to make the flanks advance faster than the central high mass. In a wetter climate on the other hand, vegetation is more easily established at the base of the dune near the water table; this impedes the wind, and causes a decrease in sand movement round the flanks, which therefore tend to lag behind the central mass. The dampness of the sand at base level will also impede its movement.

This phase is the most mobile, and such a dune can move several miles, leaving trailing parallel flanks, sometimes linked by small crossbars (see Fig. 1), behind it, and showing its path of movement, as deduced by Paul [2] for the Kurische Nehrung. Dunes in this phase are to be found at Forvie (Fig. 4a, waves 4–6), Raabjerg Mile near Skagen, and before afforestation, at Culbin.

[1] See J. A. Steers, "The Culbin Sands and Burghead Bay," *Geogr. J.* 90 (1937) 500, for a photograph of such a dune; also K. Paul, "Morphologie und Vegetation der Kurische Nehrung," *Nova Acta Leopoldina*, 13 (1944), for a contour map.

[2] Paul, K., "Morphologie und Vegetation der Kurische Nehrung," *Nova Acta Leopoldina*, 13, (1944).

As sand is left behind in the flanks, the volume of the mass decreases and the dune sometimes becomes completely stabilized by vegetation. There may now follow the second phase, of erosion, dominant in Europe; in this phase the U-shape is most clearly seen, open to the wind (Fig. 1, phase 2). The periphery is already the most stable part, but the central higher mass is more exposed to wind, and therefore to erosion which occurs in localized patches on the prevailing windward side. These patches are hollowed out to water table level, and later coalesce; an erosion face devoid of vegetation results, backed by a deposition face which is fixed by grassland or heath. A knife edge supported by decaying vegetation divides the two faces, and while this edge is intact deposition to the leeward is slow; but where the edge is broken by undermining, a wind channel may be cut through. This happens from time to time along the length of the erosion face, and usually results in a fairly regular "bow" which continues to move very slowly down-wind

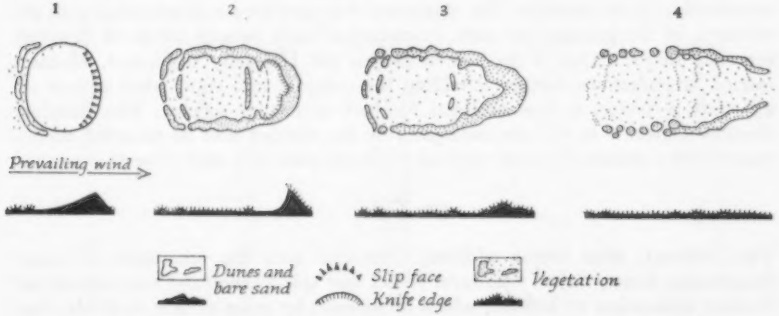


Fig. 1. Diagrammatic representation of parabola or U-dune phases

by this means. The flanks are further lengthened in this process. Dunes of this type are found, connected laterally, at Forvie (Fig. 4a, waves 1 and 2); parts of Figures 5 and 11, and locally throughout Jutland. The resulting U thus contrasts directly with the crescentic barchan which opens away from the wind.

A complete fixation of the erosion face by vegetation may result, as in the most mature wave 1 at Forvie; the majority of the Jutland dunes are of this form. Alternatively the bow may break through completely at the centre, and the new mass deposited to the leeward may break through repeatedly in a regular manner, only the long vegetation-covered flanks of the U-dune remaining, stabilized by grassland, heath or scrub (Fig. 1, phase 4). This phase, though found in Germany, is not typical of Denmark or Britain.

No attempt is made here to interpret details of European dune shape, but J. W. Van Dieren,[1] and A. Schou [2] and W. Hartnack [3] discuss these at greater length. R. A. Bagnold [4] has studied desert dune forms, and also orientation in the light of wind regime.

Analysis of environment in relation to dune orientation.—The orientation of dunes is a result of the interaction of all environmental factors. These include wind,

[1] Dieren, J. W. Van, 'Organogene Dünenbildung' (The Hague, 1934).
[2] Schou, A., 'Det Marine Forland' (Copenhagen, 1945).
[3] Hartnack, W., 'Wanderdünen Pommerns' (Greifswald, 1925).
[4] Bagnold, R. A., *Geogr. J.* **117** (1951) 78.

vegetation, local changes in topography, erosion of stabilized dunes before sand is available for movement, the effects dependent upon the variation in the angle between predominant wind direction and direction of greatest dessication, trapping of sand by neighbouring water, etc. It is to be expected, however, that wind will have the dominant effect, and it is the only factor investigated here. The effects of winds "weighted" differently in respect to the amount of rain they carry has not been considered, since rainfall data is not so detailed as the wind records; and because of insufficient knowledge as yet of the effect of moisture on the sand-carrying capacity of the wind.

A detailed analysis of wind regime is necessary in order to determine its importance in orientation, the term "prevailing wind" having little value unless it can be quantitatively expressed. Such analyses have been made in the past. The earliest was carried out by Steenstrup[1] for Danish "parabola" or U dunes. He attempted to explain the orientation of the flanks, noting that their direction could not be correlated with the coastline. He considered that their long axis coincided with the direction of the greatest per cent. frequency of high velocity winds of Beaufort numbers 10–12, except in the case of Skagen and Hansted, N. Jutland. Musset[2] carried investigations further. Dividing the compass into eight wind sectors of 45° each, a vector, c, was obtained for each sector, as follows: The Beaufort Number j, from 1 to 10, was multiplied by the number n of its recorded occurrences over a standard period; and the products were then added together so that

$$c = \sum_{j=1}^{10} nj \qquad \ldots\ldots\ldots\ldots \quad (1)$$

The resultant, after vector addition, coincided with the orientation of inner Pomeranian dunes. Schou [3] however found that this method did not account for U-dune orientation in Jutland, where he showed by more critical methods than Steenstrup, their relation to wind at Skagen and Hansted. He used an expression of type (1), but considered winds only of strengths greater than and equal to Beaufort number 4. (This will now be termed Method A.) His method, however, leads to discrepancies when applied to certain other areas, and an improved method of computing "wind resultants" is therefore necessary.

Bagnold [4] showed experimentally that the sand-moving power of a wind is proportional to the cube of its velocity above a certain value of 10 m.p.h. Schou's method, involving multiplication by the Beaufort number itself, can be shown to be equivalent approximately to multiplication by $0{\cdot}35\ v^{0{\cdot}85}$, where v=velocity in m.p.h. The effect of high velocity winds is therefore not taken sufficiently into account.

For calculating the *volume* of sand moved, in cubic metres per annum, past a fixed transverse line 1 metre long in a given direction, Bagnold [5] used an expression of the form

$$A\, n(v - V_t)^3$$

where A is a constant associated with volume of sand, and can be omitted where relative *directions* only are being considered; n is the number of occasions on which

[1] Steenstrup, K. J. V., "Om Klitternes Vandring," *Medd. dansk geol. Foren.* 1 (1894).

[2] Musset, M., "Über Sandwanderung, Dünenbildung und Veränderung an der hinterpommerischen Küste," *Z. für Bauw.* (1923).

[3] Schou, A., *op. cit.*, p. 216.

[4] Bagnold, R. A., 'The Physics of Windblown Sand and Desert Dunes' (1941).

[5] Bagnold, R. A., *Geogr. J.* **117** (1951), 80.

wind is recorded as blowing in the given direction with speed v in m.p.h.; V_t is the speed of 10 m.p.h., at which average drift sand begins to move, this corresponding to Beaufort number 3 or 4, according to whether the British or Danish scale is used.

For the deduction of the expected *direction* of dune orientation from the known wind data we therefore used a vector diagram, as has been done previously; but the length of the individual vectors, b, for each direction were no longer given by (1), but instead by

$$b = s \sum_{j=3}^{12} n_j(v_j - V_t)^3 \quad . \quad . \quad . \quad . \quad \text{(Method B) (2)}$$

TABLE I

Beaufort Number (j)	*Corresponding mean speeds in m.p.h.** (v_j)		*Values for* $s(v_j - V_t)^3$, *with* $s = 10^{-3}$, $V_t = 10$ *m.p.h.*	
	British scale	*Danish scale*	*British*	*Danish*
1	2	5·6	0	0
2	5	10·1	0	0
3	10	14·6	0	0·1
4	15	19·1	0·1	0·8
5	21	23·6	1·3	2·5
6	28	28·1	5·8	5·9
7	35	32·6	15·6	11·5
8	42	38·3	32·7	22·7
9	50	45·0	64·0	42·9
10	59	52·9	117·6	64·2
11	68	63·0	195·1	148·1
12 †	75+	67·5+	274·6	190·0

* British values are derived from the Table in 'A short course in elementary Meteorology,' M.O. 247 (H.M.S.O. 1938), p. 3, for a height of about 30 feet above sea level; Danish values from *Danmarks Klima* (Copenhagen, 1933), p. 14, for no specified height.

† The figures given for Beaufort number 12 correspond to the minimum speed for the group, since there is no accepted upper limit to the speed group.

where s is merely a scaling factor of 10^{-3}. The velocity groups assigned to the Danish and British Beaufort numbers do not exactly correspond, however. Although the difference caused in the direction of the resultants is only one of a few degrees, according to the Beaufort scale used, the error has been corrected for the two countries. Using the estimated mean wind speeds corresponding to the Beaufort number, j, given in Table I, it may be shown that, approximately, $j = 0{\cdot}35\ v^{0{\cdot}85}$ in Denmark, and $0{\cdot}62\ v^{0{\cdot}69}$ in Britain.

Analysis of wind records.—A summary of the recording methods of the appropriate weather stations is given in Table II. It is unfortunate that data are not obtainable for the more extensive Danish dune systems. All the available records were used, and were brought together irrespective of time or month (except in the case of Fernley Observatory where, from the hourly observations available, the data for 03, 09, 15 and 21 hours were selected, these being the recording times of the other British stations). The factors by which these frequencies were multiplied to give the vectors a and b are to be found in Table I. These were then summed by vector addition, and the directions of the resultants are given in Table III,

and illustrated in Figures 3–11, where the actual vector diagram is also given for method B[1].

TABLE II. AREAS INVESTIGATED

(For geographical location see Figure 2)

Dune region	*Source of data and distance from dunes*	*Period covered*	*Nature of data*
Great Britain			
Burghead Bay and Culbin, Morayshire	Coversea Skerries lighthouse (6 miles)	1943–52	Daily readings for each month and year in Beaufort Scale, at 03, 09, 15 and 21 hours from eight directions
Forvie Sands; coast dunes Aberdeen to R. Ythan	Buchanness lighthouse (12–27 miles)		
Sands of Barry, Forfar	Bell Rock Lighthouse (12 miles)		
Southport dunes, Lancs.	Fernley Observatory, Southport (7 miles)	1943–52	Hourly readings recorded as actual velocity from 32 directions
Newborough Warren, Anglesey	Holyhead lighthouse (15 miles)	1911–15	Table of total frequency from 16 directions for each Beaufort number. Interval of recording not known
Denmark			
Bovbjerg	Bovbjerg lighthouse (3 miles)	1879–1925	Tables of per cent. frequency recorded in Beaufort Scale at 4-hourly intervals (04, 08, etc.) from eight directions; taken from *Danmarks Klima*, Copenhagen, 1933
Lynvig	Lynvig lighthouse (0 miles)	1908–1925	
Skagen	Skagen lighthouse (0–10 miles)	1876–1925	
Blokkhus	Hirshals lighthouse (36 miles)	,,	
Hansted	Hantsholm lighthouse	,,	
Blaavands Huk and Fanô	Saedenstrand lighthouse (7–8 miles)	,,	

The calculated resultants were then compared with the present day pattern of nearby dunes. Detailed map records, or estimates of dune movement are not avail-

[1] In the case of the Southport data, the direction of the resultant of 32 vectors was obtained mathematically.

able for these dunes. If, however, the mechanism of dune advance discussed above can be accepted, on the basis of the investigation by K. Paul,[1] then there are grounds for believing that the orientation of the now almost fixed elongated masses which were the flanks of the original U-dunes, give an indication of the path of those dunes in a previously mobile unvegetated stage. It is in relation to these stabilized remains of once mobile dunes, which in the most regular forms correspond to the axis of symmetry, that orientation by wind is discussed. This consideration is also extended to the blow-outs of ridges formed parallel to the coastline, although the disposition of the ridges themselves is not caused primarily by wind.

Method of illustration.—The Danish dune illustrations (Figs. 8–11) are derived from maps of the Geodaetisk Institut (scale 1 : 20,000; 1 : 25,000; or 1 : 40,000), in which the closely drawn contours with representative stippling for sand give a

Fig. 2. Positions of the areas investigated in Britain and Denmark

detailed picture of the orientation of the larger masses; these have been translated into dots in the drawings.

For the illustration of the British dunes (Figs. 3–7), since the Ordnance Survey contours of 25 feet are inadequate, prints of vertical R.A.F. surveys (Scale approx. 6 inches to 1 mile) were invaluable for indicating orientation. A range of orientation of a few degrees is noticeable in most regions and this range is given numerically in Table III.

Comparison of the sand-moving wind resultant, and dune orientation, based on Schou's Method (A), and a modification of Bagnold's Method (B).—In Table III, the minimum discrepancy columns show that for certain areas a good correlation occurs between the actual dune orientation, and the theoretical sand-moving wind resultant. For a number of areas, however, the discrepancy is large. A closer

[1] Paul, K., *op. cit.*

analysis reveals that the difference between method A and B varies, the two resultants tending to coincide where fewer high velocity winds occur. With four exceptions method B gives much better results, and by this method only two of the thirteen areas, *i.e.* Burghead Bay, and Forvie part X appear entirely unsatisfactory. Method A, on the other hand, though slightly more successful for Barry Sands, the inland dunes of Skagen, Burghead Bay, and Forvie X, is for every other area more unreliable. Let us first consider the two unsatisfactory results by Method B.

TABLE III. CALCULATED WIND RESULTANTS AND NEIGHBOURING DUNE ORIENTATION

Dune region	*Range of orientation of dunes (directions are those from which dunes have moved)*	*Calculated resultants from vectors a* *Method A (Schou)*	*from vectors b* *Method B*	*Minimum discrepancy between resultant and orientation* *A*	*B*
Burghead Bay and Culbin, Morayshire	28–30° S. of W.	10° 30′ N. of W.	27° N. of W.	38° 30′	55°
Forvie part X, fixed dunes 1–3, Aberdeenshire	54–64° S. of W.	66° S. of W.	74° S. of E.	2°	42°
Forvie part Y, mobile dunes 4–7; coastal strip Aberdeen to R. Ythan	75–85° S. of E.			29°	1°
Barry Sands, Forfar	29–33° S. of W.	30° 30′ S. of W.	35° 30′ S. of W.	0°	2° 30′
Southport dunes, Lancs.	0° S. of W.	10° 10′ S. of W.	2° 48′	10° 10′	2° 48′
Newborough Warren, Anglesey ..	62° S. of W.	62° S. of W.	62° S. of W.	0°	0°
Bovbjerg	27–29° N. of W.	2° 30′ N. of W.	11° N. of W.	29° 30′	16°
Lynvig	21–25° N. of W.	2° S. of W.	11° 30′ N. of W.	23°	8° 30′
Skagen. West coast	0–6° N. of W.	2° S. of W.*	1° 30′ N. of W.	2°	0°
Inland ..	4–16° S. of W.			0°	5° 30′
Blokkhus	24–30° N. of W.	14° 30′ N. of W.	24° 30′ N. of W.	9° 30′	0°
Hansted	23–27° N. of W.	18° 30′ N. of W.*	24° N. of W.	4° 30′	0°
Blaavands Huk, ..	0–4° N. of W.	11° S. of W.			
and *Fanö*	0° N. of W.		4° S. of W.	11°	4°

* Obtained from resultants constructed by A. Schou, "Det Marine Forland", Copenhagen, 1945.

The Burghead Bay and Culbin area is one of the few in which the prevailing winds come from the landward, and so may be more easily influenced by land features, thus tending to produce a variation between the wind regimes of the dunes and the nearest lighthouse. This in fact appears to happen at the adjacent Covesea Skerries lighthouse where the effect of the SW. wind is reduced by a hill, which although only 50 feet high is very close to the lighthouse. This probably explains why the resultant both by method A and B has a NW. orientation, whereas the dunes suggest, and J. A. Steers [1] states, that the prevailing winds average

[1] In a discussion after a paper on "The Culbin Sands and Burghead Bay," *Geogr. J.* 90 (1937) 527.

approximately a SW. direction. The lighthouse data is therefore probably not sufficiently representative of the dunes to give evidence of the suitability of either method of analysis.

The second large discrepancy is obtained for region X of the Forvie Sands. The interpretation of the dune arrangement here is complicated by the marked clockwise curvature of the dune field (Fig. 4a) and by the availability of conflicting wind data from two lighthouses. The difference in the two resultants obtained from simultaneously collected data can probably be explained by the fact that the Dee valley will cause a diversion in the winds from the landward, resulting in an eastward deflection of the resultant from Girdleness lighthouse, which is situated at the Dee mouth. In comparison with this the Buchanness lighthouse resultant is therefore probably more typical of conditions at Forvie, at the mouth of the shallow Ythan valley. Orientation at Forvie is therefore considered in relation to the Buchanness data.

At Forvie there are seven waves of sand, each in the form of one or more laterally connected U-shaped dunes open to "the wind." The waves are approximately parallel, but the "arms" vary in direction. The northern waves 1–3 are fixed by vegetation, and the arms have a SW. to NE. orientation; the plateau on which these dunes rest reaches a height of over 100 feet, and is bounded to the east by cliffs of over 100 feet in height. This region named X (Fig. 4a), contrasts with the southern mobile waves 4–7 of region Y, the almost due N–S orientation of the arms here being paralleled also in the blow-outs of the narrow dune belt from the R. Ythan to Aberdeen (Fig. 4b, c). In Y, moreover, the land on which the dunes rest is barely 50 feet high, and there are no cliffs between it and the sea. Forvie can therefore be divided into two sections, X bounded by cliffs to the windward, Y without cliffs. Now the resultant by method B gives a discrepancy of 1° with the dunes of Forvie Y; by method A the discrepancy is 29°. For Forvie X, however, the different orientation of the dunes causes a reversal in the correlation, B here giving a discrepancy of only 2°. This can be explained as follows.

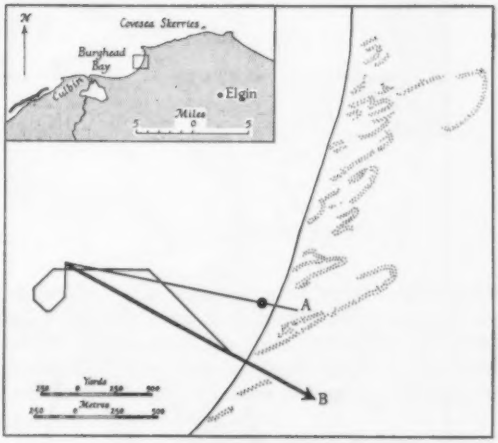


Fig. 3. Burghead Bay and Culbin

When a wind blows towards a cliff, it is deflected upwards and creates a stagnant area in the lee of the cliffs. The stronger the wind, the more pronounced this stagnant area, and in localized spots one would even expect reversed currents. (The anomalous shapes of the coastal part of wave 1 also suggest an unusual wind regime here.) In Forvie X it is the winds from the E. and SE. which will be reduced by the effect of the cliffs, and this would cause the clockwise trend in passing from region Y to X. (The greater exposure of the higher part X to winds from the

landward augment this effect. Simultaneous readings from points X and Y, Figure 4a, show west winds at X are stronger than at Y.) The Buchanness data, however, include the E. winds. Now method A fails to take the effect of strong winds into account, but B, from experimental knowledge, does. Hence the cutting

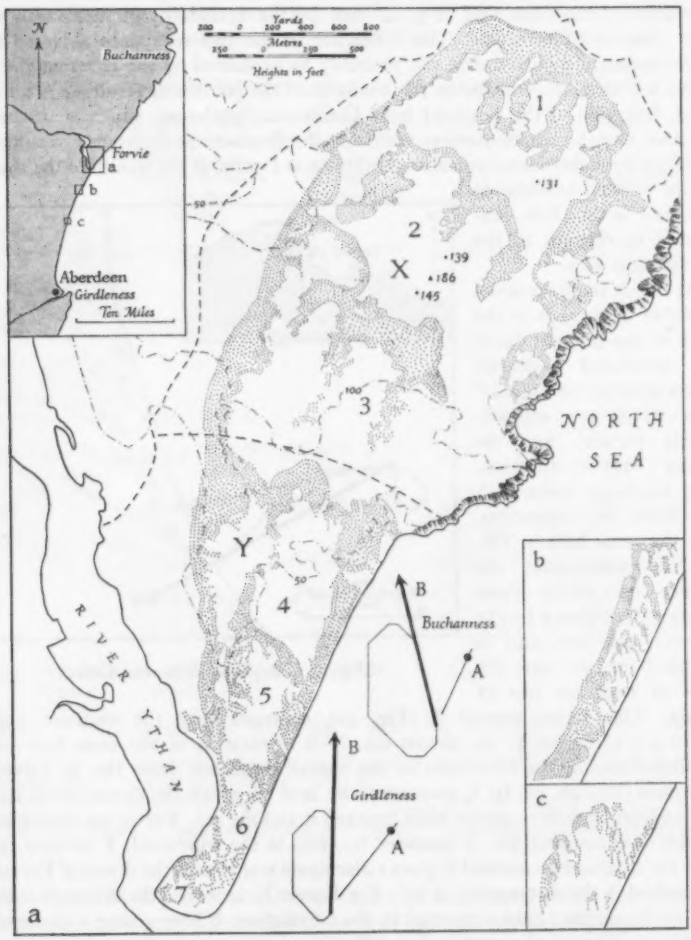


Fig. 4 (a). Sands of Forvie; (b) (c) part of coast strip between Forvie and Aberdeen

off of strong onshore winds by the cliffs explains why method A gives better results than B for this particular case.

For Forvie Y, and all other remaining British areas correlations are very satisfactory by both methods, though for Barry Sands, method A gives slightly better results; again this may be due to the reduced wind speeds over the land, as

compared with the winds recorded at the lighthouse 12 miles out to sea.

For Denmark, the interpretation is more straightforward by method B, though in the case of Bovbjerg (Fig. 8a), in particular, and also perhaps at Lynvig (Fig. 8b), results are not so convincing as in the majority of areas. An even greater discrepancy of 29° 30′ and 23° respectively, occurs with method A. For Lynvig there appears to be no satisfactory explanation since the lighthouse is very favourably placed on dunes whose orientation is clear; but at Bovbjerg the discrepancy may be caused by the situation of the lighthouse 3 miles away, on cliffs which will affect the wind regime as suggested for Forvie. In the Skagen region the wide range in dune orientation, some of the dunes being formed, incidentally, by sea currents here, shows that the wind regime is too complex to be analysed by data from the single lighthouse available. However the minimum discrepancies for both methods are small, although the maximum will be large owing to the range in orientation.

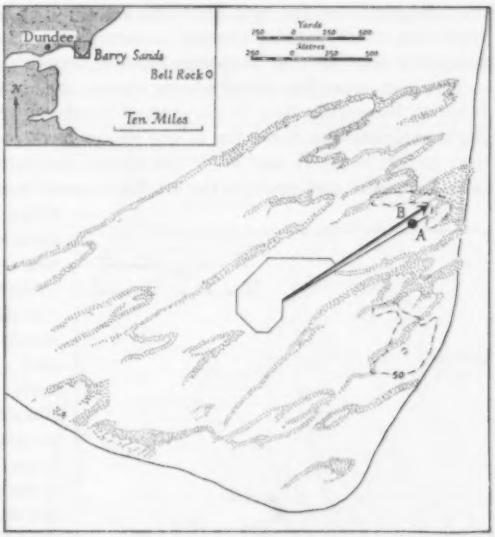


Fig. 5. Sands of Barry

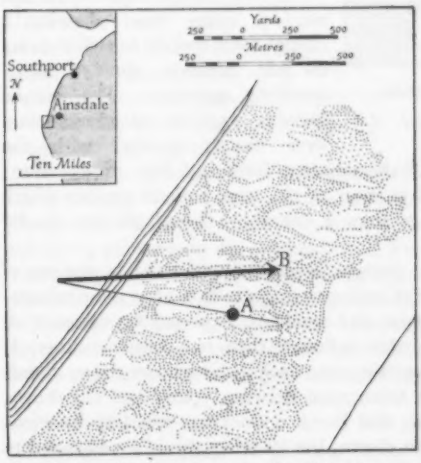


Fig. 6. Southport dunes near Ainsdale, Lancs.

For the remaining areas correlation is good, even where the dunes are poorly developed as at Blokkhus (Fig. 9b), but is always closer by method B. At Hansted the discrepancy by method A is reduced on moving eastwards along the coast (Fig. 10b). Even for Blaavands Huk and Fanô (Fig. 11), where the Saedenstrand lighthouse is situated in a region of intricate coastline, results are good.

Local variations in dune orientation within individual areas.—The attempt to explain dune orientation draws attention to the fact that a range of bearing is found in almost every area, some fields showing a distinct curvature. Three possible explanations of this are: changes in

the topography of the area over which the dunes move; the effect of increasing vegetation cover, making erosion necessary before sand movement is possible; or changes in weather over long-term periods, particularly in rainfall and wind.

The first cause has already been shown feasible in the case of Forvie, and is likely to be equally true in the case of Newborough Warren. Figure 7 shows a slight anticlockwise curvature as one moves from south to north. A hill rising to over 50 feet to the N. and W. of the section illustrated could be said to shelter the inland dunes in preference to the southern coastal ones. This hill would reduce the effect only of N. and S. winds, consequently producing the more western drift which occurs in the sheltered region.

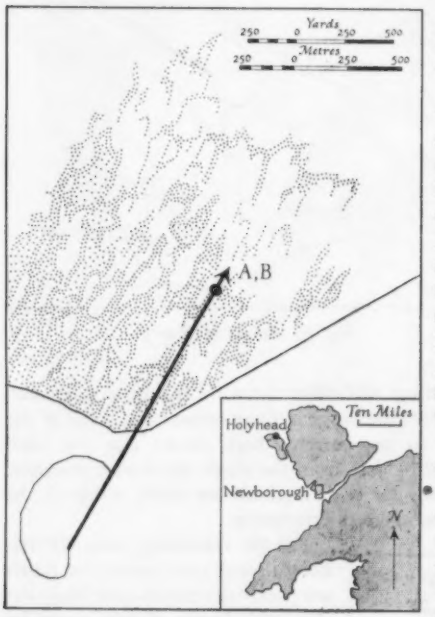


Fig. 7. Part of Newborough Warren, Anglesey

A similar, but anticlockwise, curvature towards the north can be seen on passing inland from the coast in Figure 9a; and also in the Hansted region in all maps which are more extensive than Figure 10a. It may well be the rise in land level as one moves inland which produces this curvature, as compared for instance, with the uncurved fields in Figures 3, 5, 6 and 11, where the 50-foot contour is hardly ever reached by the ground underlying the dunes.

As regards the effect of vegetation, the direction of fixed present-day dunes was established mainly when the dunes were in a mobile unvegetated stage. Even were this not so, many areas showing a change from mobile to stable dunes do not, however, show a corresponding curvature. The mobile Culbins, until recent afforestation, were exactly parallel with the stabilized phase 2 and 3 U-dunes of the adjacent Burghead Bay. In the Hansted region, on the other hand, and in most of the west Jutland regions which have not been illustrated, the dunes show a curvature though all are equally fixed.

Evidence is scanty concerning the changes in rainfall and wind in the era of blowing sand, but a change in regime of sufficient magnitude to alter dune orientation would be a widespread occurrence, and would be expected to influence all dunes in neighbouring regions, and further, influence them in a similar manner. It is therefore difficult to explain why certain areas such as Southport, Barry Sands or Fanô, should show no change in orientation between young and old dunes, Newborough Warren an anticlockwise, and Forvie a clockwise trend in direction. Information on rainfall changes is also absent, but its effect would be expected to be similar. In the light of available information, it thus appears that local changes

in orientation are likely to be caused by the effects of local topography on the wind regime.

Conclusion.—It is apparent, from the diagrams and Table III, that no general unmodified statement must be made as regards the correlations which have been calculated between orientation and wind regime. First the siting of the source of data relative to the adjacent dunes must be assessed, though this is often difficult to estimate. The very localized nature of the wind is apparent from such considerations, and is also shown by the range of dune bearing found within nearly every dune system. The assumption is also made that the period of time sampled is sufficient to represent the wind regime. Secondly, the wind data have been analysed by two methods, and the usefulness of these methods must be assessed.

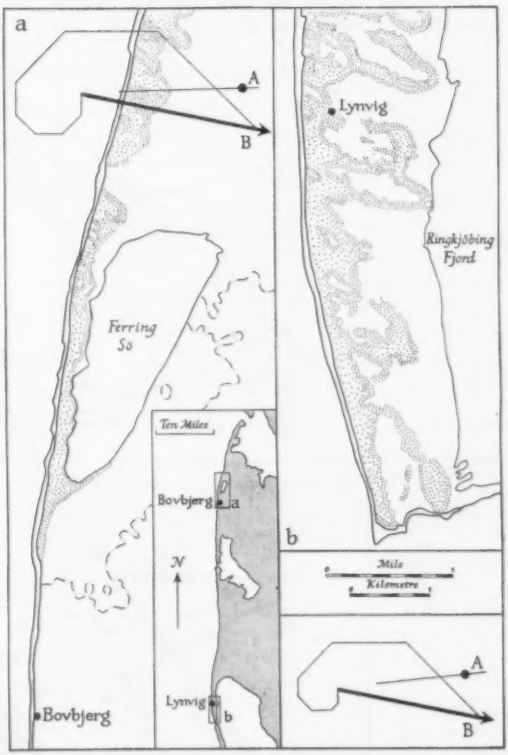


Fig. (a). North of Bovbjerg; (b). at Lynvig

Table III shows that provided Burghead Bay and Forvie X can be excluded by the arguments already stated, then method B, modified from Bagnold's experimental work, produces a reasonable correlation between orientation and resultant for the remaining areas. The earlier method A adopted by Schou, is slightly more satisfactory for Barry Sands, and Skagen Inland Dunes, and equally satisfactory for Newborough Warren, where, incidentally, only one record higher than Beaufort number 9 occurred in the sampled data. For the remaining nine areas it was less satisfactory, and very variable in reliability, probably through failing to take sufficiently into account the effect of high speeds.

Thus the calculations suggest that wind regime, as analysed by method B, is the major factor in dune orientation, and the net effect of all other environmental factors mentioned earlier is not more than one of a few degrees.

Acknowledgements

I should like to thank the Nature Conservancy for the grant which enabled me to carry out research work on the Forvie Sands; Professor Matthews of the Botany

Department, Aberdeen University, whose suggestion of an ecological investigation of Forvie led to the consideration of this problem; Drs. F. Cusick and P. T. Landsberg for their helpful criticism of the MS., and especially Brigadier R. A. Bagnold, F.R.S., for his encouragement, and the benefit of his advice.

My thanks are also due to the Meteorological Office, and Fernley Observatory, Southport, for the use of unpublished data.

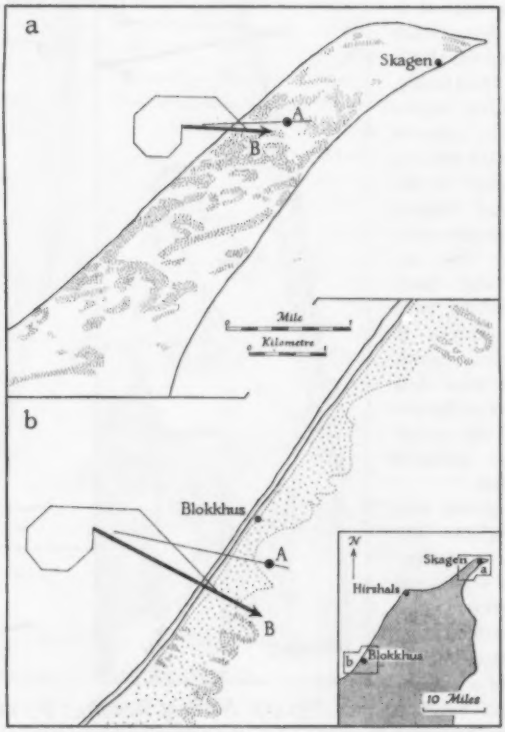


Fig. 9 (a). Skagen, north Jutland; b. Blokkhus

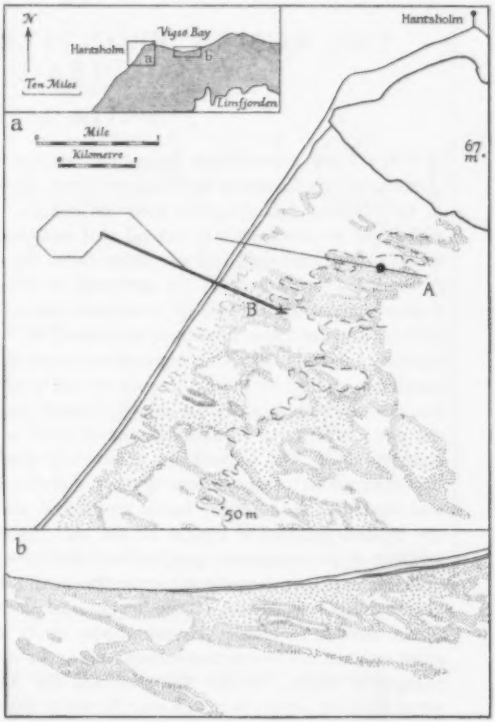


Fig. 10. (a). South of Hansted; b. east of Hansted

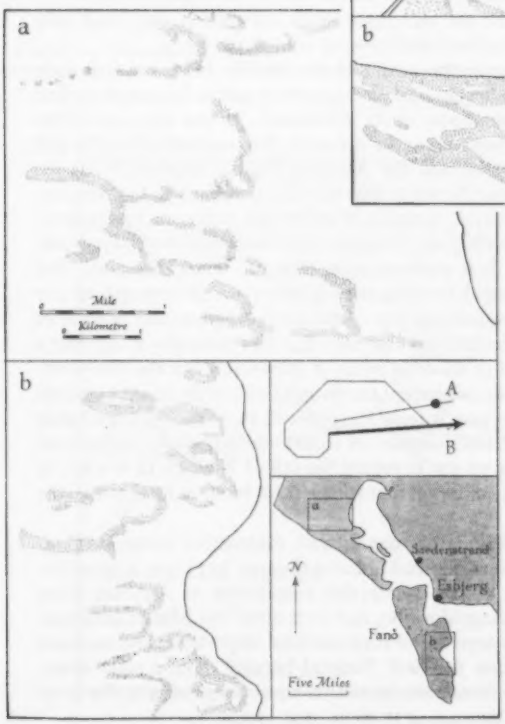


Fig. 11. (a). East of Blaavands Huk; b. southern Fanø

THE ROMAN FRONTIER IN NORTHERN 'IRAQ

DAVID OATES

IN THE YEARS immediately before the last war the late Sir Aurel Stein carried out archaeological surveys in Northern 'Iraq, a preliminary report of which appeared in this *Journal*.[1] During the summer months of the last two years I have been privileged to continue and extend this undertaking, with the aid of Stein's own unpublished material, and of grants from the Stein-Arnold Fund of the British Academy. I must express my gratitude to the Council of the Academy and the trustees of the Fund for their generous support, and also to the British School of Archaeology and the Directorate-General of Antiquities in 'Iraq* for unfailing assistance in the field. This paper summarizes a lecture delivered before the British Academy, giving an interim report on the work, the problems it presents and the manner in which they may be solved. It deals largely in generalities, for two reasons: the two centuries of Roman occupation were a mere episode in the history of the country itself, and cannot be adequately studied without a knowledge of the limitations which three thousand years of civilization imposed upon the newcomers; and secondly, the territory forms no natural part of the Roman Empire, and if we are to understand the reason or the technique of its occupation, we must take account of contemporary geographical and political considerations.

Northern 'Iraq is geographically the centre of the Middle East, and it is only necessary to visit Mosul, its modern capital, and hear four native languages spoken in the streets, to realize the complexity of its inheritance. It was also one of the great original centres of civilization and, in its maturity, the reservoir of wealth and manpower which, for six centuries, fed the Assyrian Empire, centred about the great cities of Aššur, Nineveh and Nimrud. But the very greatness of the Assyrian capitals tempts us to think of Assyria in terms of cities, and to ignore the countryside, the network of towns and villages, of minor roads and great highways, from which their power was drawn. It is perhaps unnecessary to labour the point that an ancient city ultimately depended for its luxury in peace and its strength in war not, like a modern state, on its industries, but on the land and peasantry outside its gates; and it is interesting to calculate the vast area that was necessary to support a population of 60,000 at Nimrud or twice as many at Nineveh.[2] But the prosperity of the countryside was not equally dependent on the existence of its cities; provided that there was some authority to save it from the perils of anarchy, it was probably better that the authority should not maintain its courts and recruit its armies near at hand. In fact, accustomed as we are to regard the fall of Nineveh in 612 B.C. as the cataclysm that ended an era, we forget that it may have been, in local terms, the killing of the white elephant.

Very probably there were periods of anarchy and destructive invasion. Post-Assyrian settlement on sites such as Nimrud is discontinuous, but there is considerable evidence that the pattern of the countryside established in Assyrian times continued without significant change down to, and even after, the Islamic conquest. The great cities were, it is true, deprived of their artificial importance and assumed the status that their local position justified. Nimrud became quite a small town, though large enough to inspire Xenophon to ask its name in passing [3]; the great

* Under the direction of H. E. Dr. Naji al Asil.

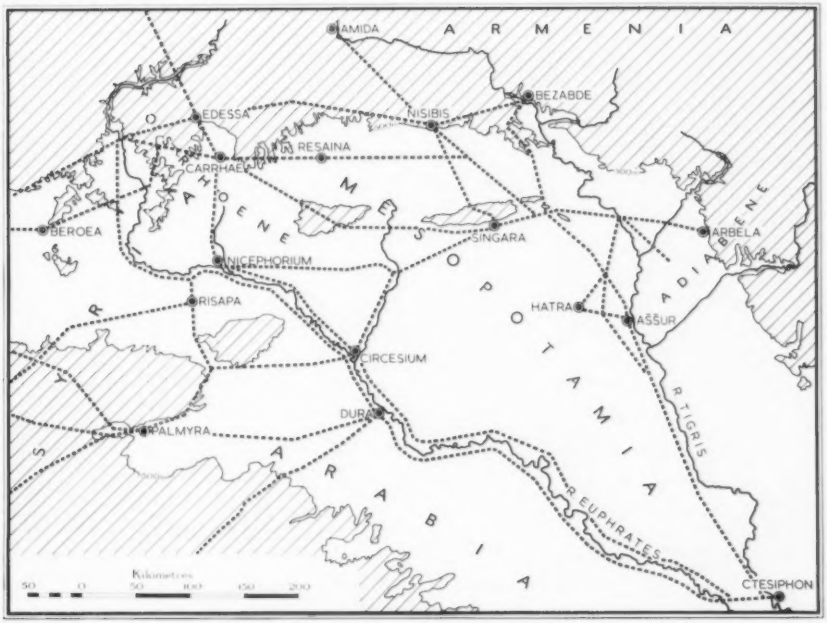


Fig. 1. Syria and Parthia c. A.D. 200

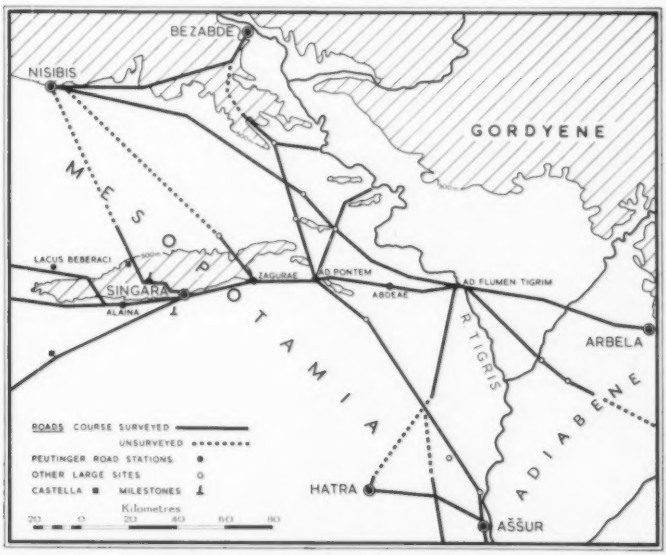


Fig. 2. Northern 'Iraq in the Roman period

Fig. 3. Plan of Singara

circuit of the walls at Nineveh was abandoned, but it remained the most important crossing of the Tigris and was known to the classical geographers—Xenophon does not mention its name, but he does record the existence of a nearby settlement under the name of Mespila, which sounds suspiciously like the modern Mosul.[4] Aššur, in virtue of its position at the point where the great highway from Anatolia to the Persian Gulf came down to the Tigris, was a larger city under the Parthians than it had been under the Assyrians.[5] And in the countryside this period of political nonentity probably fostered its recovery, not so much from the effects of the Median conquest as from the exhaustion of Assyria's imperial wars. In assessing the economic consequences of political upheaval one must distinguish sharply between conditions in northern and in southern 'Iraq where the destruction of the vast canal systems turned much of the arable land into desert; the northern plain is a region in which dry farming of cereal crops is the rule, and irrigation the exception, and although canal systems of Assyrian origin do exist, their destruction affected a comparatively small area and could not ruin a whole economy for centuries. Doubtless there were temporary recessions, and even perhaps a permanent contraction on the fringes of the Syrian desert, which were exposed to the incursions of nomads and particularly vulnerable to the encroachment of a dust-bowl. But the last ten years in this area have shown how quickly vigorous development can return much of the abandoned land to cultivation; and in general an effective continuity of occupation can be recognized in the pottery sequence on most of the sites.

It must be admitted, however, that to recognize the general outline of a sequence of occupation is one thing, and to analyse it in detail quite another; and that this essential step in the interpretation of the archaeological map is not yet possible, because no large-scale excavation has been undertaken which would provide a corpus of the post-Assyrian pottery. In fact, we know virtually nothing, in northern 'Iraq, of the local ceramic industries from the Achaemenian to the Early Islamic periods, and in attempting to date sites within these limits we have either to rely on occasional finds of imported wares, which are naturally rare in an area with such a strong pottery tradition of its own, or on generic resemblances which can give a tentative, but not a precise or reliable, chronology. This situation may soon be remedied, as the British School proposes to undertake a site of this nature in the near future; but in the meantime we must confine ourselves to the bare recognizable facts, with some account of the method by which they have been collected.

This method has necessarily been selective, for in a land where a hundred sites of high antiquity can be seen from a single hill-top, some form of selection is inevitable. The survey has therefore been based on the road-system, often the most easily recognizable feature of a Roman province; and if, as there was reason to suspect, this was not a typical Roman province, then at least a study of its communications should point to the discovery of its characteristic sites. This involved examining first what were the probable, and secondly the possible, ways of getting from place to place, taking account of such considerations as water-points, hill passes and river crossings, as well as the sort of going that each route afforded. Many of these ways had clearly remained in use for thousands of years; others, which had served temporary needs—the tracks around Hatra are a good example—are now deserted; while yet others, which had lapsed into disuse with the virtual abandonment of wheeled transport in the medieval period, have been re-opened by the coming of the motor car. The dating of these routes, a subject which must be handled with a very lively scepticism, depends on the identification of the sites they served. Some show signs of metalling, but that is no more an indication of date

than, in this area, the quality of masonry in buildings; and sometimes a road which would pass muster in the west as a Roman military highway by virtue of its bastioned *castella*, must be regretfully recognized as a medieval caravan-track with fortified *khans* at its nightly stopping places. It is not possible here to quote the evidence of individual roads, but the setting of the scene may be concluded with an outline of the historical development which their study, and the examination of related sites, has brought to light.

Some reasons have already been given for the probable survival of the Assyrian organization, and the evidence of the sites confirms this belief; on the whole, Assyrian, and particularly Late Assyrian, pottery provides the largest group of identifiable sherds. It is, of course, by no means the earliest. Prehistoric pottery is not uncommon, and a very extensive occupation, with some large town sites, is attested for the second millenium by a wide distribution of Khabur ware.[6] But the deliberate siting of Assyrian fortresses at strategic points, and the obvious association of the larger sites with the road system, suggests, as is not unreasonable, that the logical organization of the countryside may be attributed to its period as the centre of a great empire. Pottery of Hellenistic or Parthian type is also widely spread; but the difficulty of analysing it, since the great majority of the sherds are of the coarser wares, makes it at present of little use in assessing precise distributions at any given period. Broadly speaking, one may say that the Assyrian pattern is preserved, but that the fortified sites with a special purpose, and those on the fringe of the desert, dwindle in number and size, being replaced in isolated instances by new settlements which served the needs of the Parthian or, in their day, the Roman overlords. With the Sassanian period we enter on blank ignorance. Hardly a single fragment of the known Sassanian wares has been found, and the same may be said of the Umayyad and Abbasid occupation, which has left only scanty traces of the glazed pottery so common in southern 'Iraq. One can only conclude that at this time, which we know from historians to have been at least as prosperous as the preceding ages, the production of pottery was confined to local styles which borrowed little from their neighbours. This is a question which will only be solved by excavation, but the probability is strengthened by what we do know of the succeeding Atabeg period, when a local Seljuk dynasty once again ruled large parts of Syria and 'Iraq with Mosul as its capital. These rulers presided over the flowering of an art in pottery and architecture which, though not always beautiful, is highly distinctive and technically impressive; and it is interesting to notice that it was in many cases the work of Christian artisans, since this area was still extensively Christian—this may eventually explain the scarcity of imported styles in earlier times. The Atabeg dynasty, and with it the period of high prosperity, was brought to an end by the Mongol invasions of the thirteenth century A.D.; and the archaeological record is effectively closed. But before we turn from this very cursory glance at the background of history, we must notice one feature which is conspicuous throughout—the close connection between the northern plain of 'Iraq and the Khabur valley from the second millennium onwards, knit even closer by the Assyrian conquests, and turned into a political unity with northern Syria by the Roman Empire. It was this unity, with the communications which it established, that could be revived and exploited by the Seljuk Atabegs with their centres at Mosul and Aleppo; and in simple archaeological terms it means that a Roman site is very often founded on an Assyrian *tell*, and almost invariably covered by a medieval ruin-field.

Let us now consider the Roman side of the question. The accompanying map

(Fig. 1) shows the Tigris and Euphrates basin as it was in the first two centuries A.D., when the Romans were pushing their frontier to its furthest extent on the Tigris. The first thing that springs to the eye is that between Roman Syria on the extreme west and the Iranian highlands, the backbone of Parthia, on the east, there is no natural frontier. Neither river was an effective barrier; yet this was the only frontier on which Rome faced a power equal to, and a civilization vastly older than, her own, and the absence of a positive frontier policy could be a serious menace. The vulnerability of Syria, and through Syria, of Asia Minor to Parthian raids had been demonstrated by the campaigns of Pacorus in 51 and again in 40 B.C. The memory of Carrhae did not encourage Roman generals to meet a Parthian army in the Mesopotamian plains, and their only alternative way of attack involved a long and tedious march through the Armenian foothills; moreover, even the threat of invasion from across the Euphrates could seriously disquieten Rome's Syrian subjects, many of whom lived by the eastern trade. So passive defence was not the answer—Rome must either conquer or negotiate from a position of strength. Meanwhile on the Parthian side there were advantages, and also very great weaknesses. The principal weakness was the loose organization of the Parthian empire, whose directly administered core consisted merely of a long strip of territory from Ctesiphon north-eastwards to Khorassan. The Parthian title "King of Kings," grandiose as it sounds, really expresses the dependence of the monarch on his powerful nobility, who might at any moment put another member of his family on his throne. Moreover, the army, whose great merit was its mobility, owed this characteristic to its amateur status as a levy of the nobility and their retainers, and had in full measure the amateur's prejudice against a long war. So the King of Kings was, curiously, liable to lose his throne either through defeat or through a successful but overlong campaign. On the other hand, Parthia had the priceless advantage of the Achaemenian inheritance, which gave her a homogeneity of culture and outlook with all the lands that had once been united under the Persian Empire and had subsequently escaped a high degree of Hellenization. This meant in effect that once the Romans stepped out of Syria or the western provinces of Asia Minor, they were in potentially hostile territory.

Rome had two answers to this problem, one a policy and the other a dream. The first sprang from Pompey's settlement of the eastern frontier, and appealed to the cautious conservatism of Roman administrators; in principle, it envisaged the creation of buffer states with client princes, often of Parthian stock or culture, but under Roman control, and its defect was that the control depended on constant vigilance and frequent, effective military action. The dream sprang from Alexander; it was the conquest of Parthia, and its defect was that it was impossible. Julius Caesar might have carried it a long way, but his plans, as interpreted by Antony, were such a disaster that the idea was effectively discredited until Trajan. The first century A.D. reveals broad adherence to the ideas of Pompey, maintained by occasional forays such as the classic Armenian campaigns of Corbulo. Possibly, if we could yet read a historical development into the Syrian frontier map of Father Poidebard,[7] we might also find a gradual extension in the plains to affirm Roman control of the kingdom of Osrhoene, with its capital at Edessa; at all events we can now see a similar move on the Parthian side, in the foundation about A.D. 50 of Hatra,[8] a hedgehog fortress controlling the approaches to Ctesiphon, and a religious centre for the Arabs of the desert, who were thus brought more closely into the Parthian orbit. At about this time, too, the dependent kingdom of Adiabene about Arbela was reduced to the second rank of vassal states.[9]

Trajan, in his campaigns of 115 and 116, attempted the conquest of Parthia, perhaps not realizing the impregnable strength of the Iranian highlands. He made Mesopotamia as far as the Gulf, and Adiabene, into Roman provinces, an indefensible position which was promptly abandoned by Hadrian two years later. But Trajan's campaigns, if not his annexations, are of interest to us, since they embody the strategy of a great Roman general and foreshadow the measures that were eventually taken to hold Mesopotamia. He gained control of the north by a campaign in Armenia, the most vital and difficult of the client states, which was followed by the creation of a base at Nisibis, the capture of Singara and the linking of the two with a military road. This gave him the mastery of the northern plain, the focus of the contested lands; but it was not simply an annexation of rich territory, nor was defence his object, but rather the establishment of a stronghold from which attacks could be launched in any direction. And some such interpretation is clearly necessary of the desire, which became a principle of later Roman policy, to hold northern Mesopotamia, since the creation of such a salient frontier, with its northeast flank directly exposed to the Kurdish mountains, cannot have been seriously conceived as the best available defensive line. Moreover, its advantages as an offensive base are clear. By holding the Tigris crossing at Mosul it threatened Adiabene, an important province in itself, and more important as Parthia's military link with Armenia. With Adiabene neutralized the Armenian question would be rendered innocuous. Secondly, it was an open threat to Ctesiphon; it was not the gay advance down the Euphrates from Syrian bases in spring, but the terrible retreat in late summer that turned attacks on the Parthian capital into Pyrrhic victories. It is true that these threats in themselves would never conquer Parthia, but either of them could unseat a Parthian king.

The history of the Mesopotamian frontier is the history of the establishment, employment and defence of this advanced base. It falls into two phases, the first from the definitive creation of the province in the second half of the second century to the middle of the third; and the second phase from that time until the Roman withdrawal to a more logical defensive line in 363, when northern 'Iraq was finally abandoned. The first phase is one of moderate success against a declining Parthia, the second a catalogue of failures against the rising power of the Sassanians. Of the campaigns of Lucius Verus from 163 to 167 we know little in detail, but they appear at least to have secured Roman control over the land west of the Khabur river; and by the end of the century the frontier was fixed on a line running westwards from the Khabur along the southern slopes of Jebel Sinjar, the mountain massif which dominates the Arabian plain. Septimius Severus raised three new legions for his attack on Ctesiphon, and afterwards left two of them, the First and Third Parthian, as the permanent garrison of the province. This garrison must have been supplemented with auxiliaries, but the only unit whose name we know is a cohort of Moorish cavalry, perhaps one of those which originally captured Singara under Trajan's general Lusius Quietus, and left their name at a site, Castra Maurorum, mentioned by Ammianus Marcellinus in the fourth century.[10] It is interesting to notice how the dedicants in the temples of Hatra at this time reflect apprehension at Roman activity—their statues once again, as at the time of Trajan, depict them in military dress; and one suppliant calls on Samya the eagle, patron of Hatra, in a fine phrase bewailing "the weakness in the soaring of Samya."[11]

At this time the civil capital and military hub of the province was Nisibis in south Turkey, and the legions were stationed here and at Singara or, perhaps more likely, in a camp covering the pass some twenty miles to the east. What provision

was made for the holding of the Tigris line is not clear; Ammianus implies that the Camp of the Moors was in this region, but it has not been certainly identified on the ground. The modern town of Nusaybin retains few vestiges of its ancient importance, but the walls of Singara, now Balad Sinjar, can still be traced over a large part of their circuit, though they too have suffered much from the stone-robbing and lime burning activities of later builders. The town was a settlement of considerable antiquity and is mentioned in Assyrian records. After its surrender by the Romans in 363 it lost its special importance, but revived in the Early Islamic period and reached its zenith under the Atabeg dynasty; it again declined in the later Middle Ages, and remained comparatively insignificant until the return of security and prosperity brought a new expansion in the last thirty years.

The nucleus of the town, and probably the site of the original settlement, is a steep-sided hill on the east of the watercourse, with a small citadel, now unfortified but still known locally as the castle, at its upper end [12] (Fig. 3). The Romans fortified the site, at the same time doubling its area by carrying the walls across the valley and along the crest of the opposite ridge, so as to include the perennial springs in the low-lying ground west of the watercourse. Under the Atabegs even this area was exceeded—the wall was built over, and the town extended about half a mile to the south-west. In consequence any buildings of the Roman period that may have stood within the walls are buried under mounds of rubble, and only the line of the main north–south street can be detected. In the older part of the town the wall is completely lost among the existing houses, though the ancient road, and modern caravan track, coming in from the east suggests an original gate at the head of the present market street, and from here to the citadel another street seems to preserve the line of the ditch. In the western, largely deserted, quarter the course of the wall and the position of the towers can be traced, but very little of the masonry has escaped the lime-kilns. There are, however, enough features surviving to show that the defences consisted of a ditch about fifteen metres across and still, in places, up to 3 metres deep in solid rock; its inner face was retained by a counter-scarp built of drafted masonry, with the main wall, over 3 metres thick, about 8 metres behind it. The towers, which were U-shaped in plan, projected from this wall at intervals of some 80 metres, with a pair guarding each main gate; they were at least two storeys high, but the means of access to the upper storey is not visible. The facing is of dressed limestone blocks throughout, in courses of approximately 40 centimetres, with a concrete core poured and levelled course by course.

The arch of the Roman south gate, through which passed the roads from the lower and middle Khabur, can still be seen just to the west of the stream-bed (Fig. 4). It was blocked in the medieval period, and more recently re-used as the foundation of a house, now abandoned; the stonework on the outside above the arch is a refacing on the earlier concrete core, but the voussoirs, and the lower courses of the wall on either side, are original. Water emerging from a conduit below road level now feeds a bathing pool immediately outside the gate; the conduit is tapped by well-heads within the town, and its original purpose was probably to spread the outflow from the springs, which would otherwise have required a dangerously large passage through the wall. The interior of the gateway is filled to a height of some 3 metres with the debris of the two later buildings; the visible Roman masonry outlines two long recesses on either side of the roadway, but it is impossible to say without extensive clearance whether there were any internal partitions. In recent times it was a store for the house above, but the medieval piers, indicated by close hatching on the plan, support concrete vaults of the type much

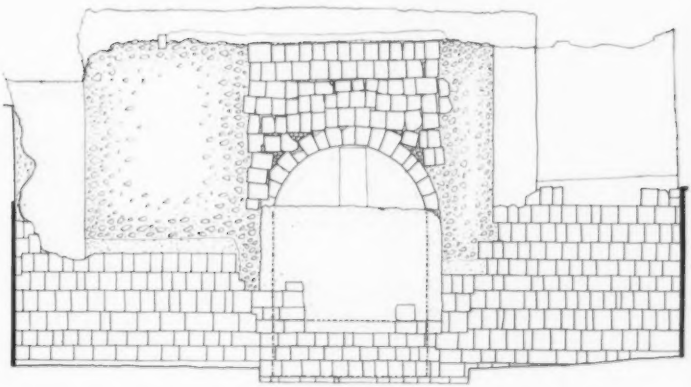
used by Atabeg masons, and their arrangement makes one curious about the local tradition that there was once a church on this site. The road itself is not visible, but a sounding on the site of the north gate in 1955 revealed it at that point, and incidentally cast a gloomy light on the prospects of more general excavation. The area within the gate had been paved with limestone slabs about 40 centimetres square, continued on the outside by a concrete causeway leading across the ditch to the Nisibis road. The whole structure had been cleared in Atabeg times, and the paving stones and walls coated with bitumen plaster, presumably for habitation; but the debris of this re-occupation, and the collapsed upper part of the gate itself, had been lately dug over and the limestone blocks removed to a kiln on the site of the adjacent gate-tower. We found two surviving blocks bearing the moulding of a large *tabella ansata*, but the building inscription which they probably enclosed had completely disappeared.

Some evidence of the date of the fortifications is, however, afforded by the best surviving stretch of the wall, along the crest of the western ridge. Bastion No. 5, at the south-west corner, has been incorporated in the foundation of a modern house, and its interior, preserved up to first-floor level as the courtyard of the present building, gives us our best example of Roman masonry. But it is to the more ruined bastions, Nos. 6 and 7, that we must look for the distinctive details they reveal of the original layout of the defences (Fig. 5). The ditch is clearly marked, with the counterscarp standing to a height of over 2 metres on the north side of bastion No. 7. Its masonry has been removed elsewhere, but the line of the robber trench can be traced around the tower on the west and south-west, and running parallel to the wall, on the inner lip of the ditch, as far as bastion No. 6, which it skirts in the same way; the seating for one of its blocks, cut in the rock outcrop on which the tower is founded, gives its exact line. Access to the glacis behind it was gained by a postern gate under the protection of the angle bastion; it was blocked by medieval revetments, but one of its jambs can be seen just south of the ruined tower.[13] Bastion No. 6, which also owes its preservation in part to re-use in the medieval period, gives us a complete ground plan, with the position of the radial slit windows in the lower storey; their inaccessibility, at a height of 3 metres above the floor, and their small field of view make it probable that their purpose was lighting rather than defence. The medieval repairs, here and elsewhere, are clearly distinguished from the Roman masonry by the darker colour of the mortar, which contained a high proportion of kiln ash, and the dating criterion afforded by this marked difference has proved especially useful on other sites, where medieval *khans* often copy very closely the plan, as in part they served the purpose, of Roman *castella*.

The defences of Singara, with the ditch, outer and inner walls and salient towers, are obviously in the tradition of late Roman and early Byzantine fortification, designed to resist assaults conducted with all the resources of siege-craft, and whose greatest example is the Theodosian wall of Constantinople in the early fifth century. Ammianus Marcellinus [14] gives an account of the last siege of Singara by the Sassanians in 360, when a large battering ram eventually caused the collapse of a recently repaired round tower, and goes on to tell us that the place was captured, as it had been many times before, with the loss of its whole garrison. This implies that the walls were built, at the latest, in the first half of the fourth century, and incidentally demonstrates that the wall of Constantinople was not, as has been suggested,[15] the archetype, but the grandiose culmination of the development of this style. Singara has a close, though more refined and elaborate parallel in the

SINGARA

The South Gate



Elevation

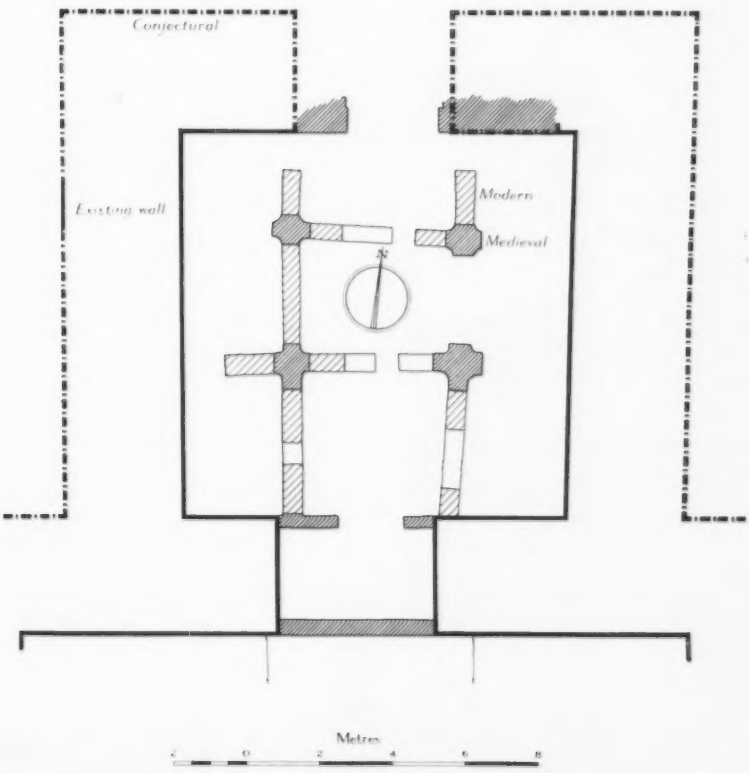


Fig. 4. Singara—the South Gate

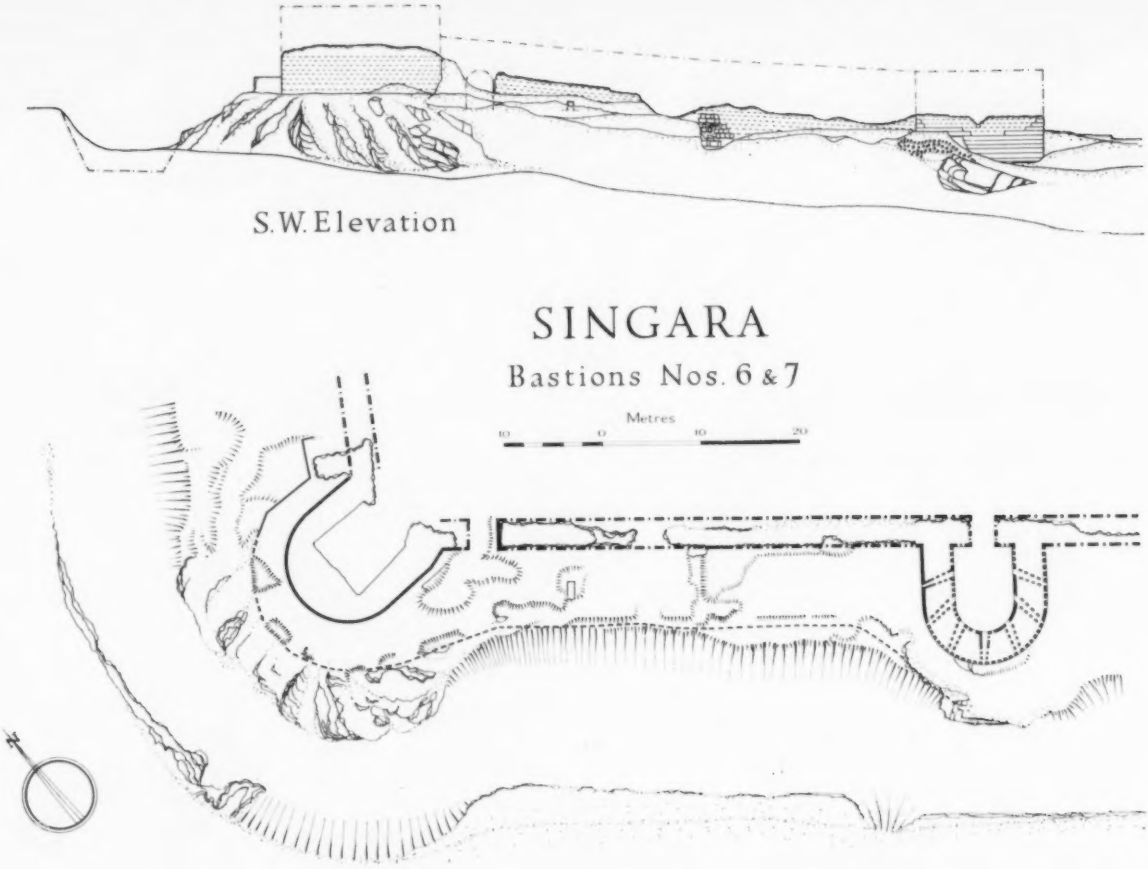


Fig. 5. Singara—Bastions 6 and 7

larger Mesopotamian city of Amida on the Tigris 150 miles to the north-west.[16] The date of the walls of Amida is the subject of a controversy in which one who has not seen the site cannot properly intervene, but it may be useful to recapitulate the evidence briefly here. An Arabic inscription, *in situ*, dates the walls in their final form to A.D. 1068, but this can hardly be taken literally, since there is good authority for their construction or reconstruction on three earlier occasions. Ammianus, who had personal knowledge of the place, states [17] that it was quite a small town when it was enlarged and fortified by Constantius II about 330. A Latin inscription,[18] re-used in the Islamic masonry, records a building "*a fundamentis*" under Valentinian, Valens and Gratian, which must be dated about 370, and probably represents the strengthening, and possible extension, of the city after the surrender of Nisibis and the re-settlement of its evacuated population. And Procopius [19] claims that the walls were built by Justinian; Byzantine activity is certainly attested by Greek inscriptions bearing the name of an official responsible for fortifications.[20] Since only one circuit of walls survives, and no obvious alterations of design have been identified by recent surveys, it seems reasonable to suggest that the sixth and eleventh century builders repaired or reconstructed on the lines laid down in the fourth century, and that the pattern, if not the existing masonry, can be attributed Constantius II; in the same way the walls of Constantinople preserved through many repairs and additions the principles laid down by Theodosius. If this is accepted, then both Amida and Singara can be regarded as early fourth century prototypes of a defensive technique later adopted by Byzantines and Arabs alike,. and this is the more reasonable when one remembers that it was the Sassanians who first learnt from, and practised against, the Romans the mechanical arts of siege-craft, and that Mesopotamia was their battle-ground.

East and west from Singara ran the ancient highway from Nineveh to the Khabur, adopted by the Romans for their frontier road and, presumably for this reason, recorded in the Peutinger Map as a devious route from Singara to Hatra : [20] *Singara* XXI *Zagurae* XVIII *ad Pontem* XVIII *Abdeae* XX *ad flumen Tigrim* XX (unnamed station) XXXV *Hatris*. The course of this road can be traced on the ground (Fig. 2), as a trough up to 20 metres wide and 5 metres deep, along the southern foothills of the Sinjar range, rounding the northern end of Jebel Ibrahim above Tell Afar, and thence running straight across the plain and over Jebel Atshān to the Tigris crossing opposite Nineveh. It is lined with sites of all ages, among which the Roman road-stations can be identified with fair confidence from the distances recorded on the ancient map. Twenty-one Roman miles eastward from Singara takes us past the great Atabeg *khan* of Al Han with its sculptured gateway, to the perennial springs of Ain Sinu.[22] From this point a road, older than Trajan's direct but difficult route over Jebel Sinjar, leads across a low saddle to Nisibis, and it is not surprising that we find this important junction held by a Roman legionary camp of the traditional type, obviously the station Zagurae. The fort cannot be accurately dated without excavation, but it appears from superficial examination to be an early feature, perhaps the original nucleus, of the straggling settlement around it. It is not a temporary camp, since there are traces of a stone perimeter wall and the outlines of permanent quarters in the long parallel mounds, or *strigae*, which occupy the interior; and it seems possible that it was an earlier, as indeed it is strategically a more obvious legionary base than Singara. Passing on from Ain Sinu, a further 18 miles brings us to the Turcoman town of Tell Afar, where a deep gorge at the foot of the Assyrian citadel explains the name "ad Pontem." Medieval and modern occupation has effaced the traces of any Roman

building, but this is the only watercourse between Singara and the Tigris which would always require a bridge for its crossing, and the placing of a road-station here is supported by other considerations. Tell Afar too was a road junction of importance, where the highway from the south, forced to abandon the Tigris valley by the broken country north of Aššur, crossed the Singara road and then the hill range on its way to Nisibis and Anatolia. Following the frontier road eastwards, at a distance of 18 miles from Tell Afar we come on an abandoned town site, close to the present village of Gonaisiya. Its visible remains are of the medieval period, including a large fortified khan, but sherds of red burnished pottery of fourth century type point to Roman occupation, and its position corresponds exactly with that given for Abdeae on the Peutinger Map. From Gonaisiya to the Tigris at the north end of Mosul the road is particularly well marked, though any settlement at the crossing has been obliterated by the later town. At this point the main road from Nisibis to Arbela comes in from the north-west, and another track leads south-westwards to Hatra, presumably the route indicated by the Map with a total distance of 55 miles and an unnamed intermediate station; the actual distance is in the region of 60 Roman miles, but this is no great discrepancy, and in fact alternative routes give a much larger error.

This highway is representative of the large majority of those examined, although of course we rarely have such precise evidence for the identification of sites; and it is noteworthy that neither the road nor its stations, with the possible exception of Zagurae, are of Roman origin. It appears indeed that Roman innovation in this field was confined to a few military roads designed to link the new territory more firmly with the west and north. Trajan's road joining Singara directly to Nisibis has already been mentioned, and it has been possible to trace its course from the 'Iraq frontier near the village of Khan as-Sūr, where there is a Roman *castellum*, to Karsi on the north side of Jebel Sinjar, where Cagnat in 1927 saw one of its milestones [23]; and thence by carefully engineered gradients over the crest of the mountains to the north gate of Singara. A second milestone discovered 3 miles southwest of Singara in 1951 [24] can be assigned to a road, seen crossing the Syrian frontier by Poidebard, which linked the town with the lower Khabur, and the inscription dates the construction or repair of this road to the year 233, during the Mesopotamian campaign of Alexander Severus.

Taken in conjunction with three newly discovered Latin inscriptions from Hatra, this throws new light on the turning point in the affairs of Mesopotamia in the second quarter of the third century, and may fittingly be used as an epilogue to this general survey of Roman activity in 'Iraq, since it hints at the key to the problem. In A.D. 226 the Arsacid dynasty of Parthia was overthrown by the Sassanians, and this gave Rome a temporary advantage which she was quick to seize. Alexander Severus attacked with his army in three divisions, one operating in Armenia, another on the Euphrates, and the centre, under the emperor himself, advancing eastwards through Mesopotamia presumably using the Khabur–Singara road as his forward supply line. The campaign is unfavourably reported by historians, who record the piecemeal defeat of the wings by Ardashir I, but make no mention of the centre division. It has been suggested above that the general aim of Roman policy was to gain control over the northern dependencies of Parthia, and it now seems that the specific object of Alexander Severus was just this; for the group of three dedications in one of the temples at Hatra,[25] dated between 235 and 244, records the presence of Roman troops for the first time within her walls—the 9th cohort of Moors, under the command of a tribune of the First Parthian legion.

It is not likely that this success was achieved by the use of force, but rather that the show of it persuaded the Hatrenes, deprived of their former allegiance by the change of government at Ctesiphon, to accept the new alliance. But it is ironical that the last of these dedications celebrates a victory over the Sassanians with the words "domita Midia," for within twenty years Shapur I, his eastern provinces subdued, had sacked Hatra and Dura and was at the gates of Antioch; and thereafter Rome was on the defensive in a position which could not be defended. We have not yet the information to trace the course of the struggle against this new and more energetic adversary, some hint of whose power can be deduced from the fortifications of Amida and Singara and the personal narrative of Ammianus Marcellinus; but it is to be hoped that further work on the lines suggested in this paper may eventually make such an account possible.

REFERENCES

[1] *Geogr. J.* **92** (1938) 62, and **95** (1940) 428.

[2] These points were discussed in 'Assyria and the Old Testament,' Schweich Lectures, 1955, by Professor M. E. L. Mallowan, to whom I am also indebted for much information and advice.

[3] *Anabasis*, IV, 7.

[4] *Anabasis*, IV, 10.

[5] Andrae, W., and Lenzen, H., 'Die Partherstadt Assur.' Leipzig, 1923.

[6] Mallowan, M. E. L., '*Iraq*, **4** (1937), p. 103. A survey of sites in the Sinjar region, which has been of considerable use to me, was carried out by Seton Lloyd, '*Iraq*, **5** (1938), pp. 123–42.

[7] Poidebard, A., 'La trace de Rome dans le désert de Syrie.' Paris, 1934.

[8] For this and other information about recent discoveries at Hatra I am indebted to the courtesy of the Directorate General of Antiquities, Government of 'Iraq; and especially to Dr. Fuad Safar, for invaluable discussion and criticism.

[9] Josephus, 'Antiquities,' XX, 81–91.

[10] XVIII, 6, 9, and XXV, 7, 9.

[11] See n. 8, p. 000.

[12] The survey of Singara is the joint work of the writer and Mr. Geoffrey Clarke, A.R.I.B.A., who is responsible for the plan and the architectural drawings accompanying this article.

[13] This gate would have been of little use unless masked by the counter-scarp, whose parapet must have been carried up to a considerable height; but the point is too speculative to be included in the drawing.

[14] XX, 6, 3–9.

[15] Berchem, D. van, "Recherches sur la chronologie des enceintes de Syrie et de Mesopotamie," *Syria*, **31** (1954), p. 266.

[16] Gabriel, A., 'Voyages archéologiques dans la Turquie orientale.' Paris, 1940, pp. 85–182; see also D. van Berchem, *op. cit.*

[17] XVIII, 9, 1.

[18] C.I.L., III, 6730.

[19] 'Buildings,' II, 3, 27.

[20] Gabriel, A., *op. cit.*, p. 161.

[21] 'Weltkarte des Castorius,' ed. K. Miller, Ravensburg, 1888, Segmentum XI, 5.

[22] A sketch plan of Ain Sinu was published by Sarre and Herzfeld,' 'Archaeologische Reise im Euphrat und Tigris Gebiet,' Vol. II, Fig. 283, under the name of Ain al Shahid, now unknown locally. They correctly identified the site as Zagurae.

[23] Cagnat, R., 'Syria,' VIII (1927), p. 53.

[24] *Sumer*, **8**, Pt. 2 (1952), p. 229.

[25] Oates, D., "A Note on three Latin inscriptions from Hatra," *Sumer*, **11**, Pt. 1 (1955), pp. 39–43.

THE GEOGRAPHICAL MAGAZINE AND ITS TRUST FUND

THE *Geographical Magazine* needs no introduction to Fellows or Associate Members or readers of the *Journal*. Because of the long and close association between the Society and the magazine ever since the latter's foundation, Fellows receive the magazine at specially favourable rates and Associate Members, if they wish, receive it as an alternative to this *Journal* as one of the privileges of membership. But there is more in the magazine than meets the eye. Linked with it is the Geographical Magazine Trust Fund which receives a large proportion of the Magazine's profits declared as dividends each year. These profits are distributed by the Geographical Magazine Trustees in the form of grants for exploration and research, and for the promotion of geographical films and lectures. Many geographers and travellers and, for that matter, the Society itself, have good reason to be grateful to the Trustees, and through them to the generous and far-sighted founders of the magazine, for these various benefactions which, since 1945, have amounted to a total not far short of ten thousand pounds. It is a record of disinterested service to learning which must be unique in the world of commercial publications and it is one which gave the Magazine Company, the Trustees and the Society good cause to celebrate recently the magazine's coming of age.

The *Geographical Magazine*, whose founder and present editor is Michael Huxley, was launched in October 1934 when the Company was incorporated. But the idea of a geographical magazine was not new in 1934. In the eighteen-seventies, Sir Bartle Frere, President of the Society, Mr. Clements Markham, then an Honorary Secretary, and some other members of the Council having decided, in the words of Hugh Robert Mill, that the Proceedings of the Society at that time were "imperfect, dull and formal," proposed to launch a geographical magazine with Markham as the editor. Their hope evidently was that this might be a publication of the Society. The majority of the Council, however, were against it. Perhaps they feared that the dignity of the Society would be impaired if it were to sponsor a more "popular" geographical periodical. But Markham, characteristically, was not deterred. The magazine was launched as an independent publication under his own editorship, first with the title "Ocean Highways," later as "The Geographical Magazine." For six years the new publication appeared monthly and included accounts of current explorations, papers about the geography of countries in the news as a background to current affairs, proceedings of the Royal Geographical Society and of foreign geographical societies and, as a special attraction to the insatiable Victorian mind, "a Log Book containing notes and information not to be found elsewhere." The new magazine soon had a steady subscription list of over a thousand including, as the Society was not slow to notice, a large proportion who were not Fellows of the Society though they were keen supporters of geography.

But costs were high, and capital was lacking, and with little in the way of editorial staff, the burden bore heavily on the unpaid editor, Clements Markham. It soon became clear that the magazine could not be carried on for much longer unless it could be placed on a sounder business basis and the proprietors, Messrs. Trubner and Company, were bold enough to approach the Society for a subsidy which they hoped might be forthcoming "in the interests of geographical science." The

Council's answer was as robust as it was unequivocal. The Society would not subsidize any magazine which was not under its direct control. Nevertheless, the initial success of the magazine and the tempting "new geographical realm to be annexed to the Society from among those of the subscribers who were not Fellows," had not escaped the Council's notice. The Society decided, rather than subsidize the existing magazine, that it would be more prudent to reshape and improve its own Proceedings so that these, when the time came, could take the place of the magazine and attract to it the magazine's subscribers. This prospect, with its threat of competition from so powerful a body, was less attractive to the proprietors of the magazine, to whom Markham felt some consideration was due for all their efforts to create a valuable geographical periodical. In the end, the Society was obliged to buy the copyright of the magazine and it was absorbed into the new Proceedings of the Society.

Perhaps the founders of the present *Geographical Magazine*, more than half a century later, had some memory of these past events in mind. In 1934, when the magazine was founded, it was "with the knowledge and approval of the Royal Geographical Society." The Company moreover undertook that it would not "trench upon the functions of the Royal Geographical Society" in any way. A further insurance against any possibility of friction was provided in the composition of the Geographical Magazine Trust Fund, which was set up in 1937. The Trustees on the one hand were established as a body quite independent of the Society, with absolute discretion to act within the broad terms of the Trust. But the Chairman of the Trustees was to be the President of the Society for the time being and two out of the remaining four trustees were to be appointed by him from among members of the Society's Council.

But these personal links between the Trust and the Society are of less importance than their fundamental identity of aim. By the Deed of Trust, the Trustees were entitled to one thousand "C" shares in the Company enabling them to receive one-half of the Company's annual profits declared by way of dividend or bonus. These profits are devoted to the advancement of geography in the form of grants for geographical exploration and research, for the production of geographical books, monographs and films, and for the delivery of lectures. In these and other ways, as for example in the foundation just after the War of a travelling fellowship for research, the magazine has helped substantially to forward the aims of the Society. The Society has also benefited in more direct ways. The very up-to-date equipment it installed after the War for the projection of sound films was made possible by a grant from the Trust Fund, and the expenses of many distinguished foreign lecturers to the Society have been covered from the same source. This association with the Society is helpful to the Trustees who, in deciding upon grants, have always at their disposal the advice of the Society. The Trustees, for their part, help to promote the interests of the magazine, their source of revenue, by directing to it, as they are bound to do, articles and photographs for publication from geographers and travellers who have received grants from the Fund.

Recently, the Trustees have been able, through the generosity of an anonymous donor, to take advantage of their option to acquire further shares in the Company and they now hold a controlling interest. They will in future receive not one-half but three-quarters of the annual dividends. There is thus a prospect, though it may not be an immediate one, of larger sums being available for geography provided the magazine can expand its present circulation. That such an expansion is in the interests of the Society and of the causes it represents is obvious, and no

doubt Fellows and Associate members, here and abroad, will help. The circulation, distribution and business management of the magazine has recently been taken over by *The Times* Publishing Company. That, in itself, is a happy augury though in no way does it diminish the debt which the Company owes to the former publishers, Messrs. Chatto and Windus, for their large part in helping to bring the magazine to its present flourishing position. Meanwhile, the skilful and imaginative editorship of Michael Huxley is a guarantee that the highest standards both of text and illustration will remain the pattern for the future. The *Geographical Magazine* may not be the child of the Society (as Clements Markham hoped "Ocean Highways" might become) in the sense of being one of the Society's own publications. But it is at least a cherished young relation whose progress (and behaviour) during the first twenty-one years of life have been most gratifying, and with whose welfare our Society is intimately concerned.

BRITISH NORTH GREENLAND EXPEDITION 1952–4: SCIENTIFIC RESULTS

R. A. HAMILTON AND OTHERS

A MEETING WAS held by the Society on 14 November 1955 to hear some of the scientific results of the British North Greenland Expedition. Since a general description of the Expedition's work had already been given by the leader, Commander C. J. W. Simpson, R.N., at the meeting held by the Society in the Royal Festival Hall on 29 November 1954 (*Geogr. J.* **121** (1955) 274–89), it was possible to devote this later meeting exclusively to technical matters. R. A. Hamilton, deputy leader of the expedition, summarized papers by Lieutenant F. R. Brooke, R.N., and K. C. Arnold (surveyors), and by Flight-Lieutenant S. Bowater, R.A.F., in charge of air photography. It had unfortunately proved impossible for the authors of these papers to be present; Mr. Arnold was in Canada and Lieutenant Brooke at sea. Mr. Hamilton also gave an account of the trigonometrical levelling across the inland ice carried out by W. S. B. Paterson and C. G. M. Slesser, and mentioned the research done by other scientists. H. Lister, who was two years in Dronning Louise Land as senior glaciologist to the expedition and Dr. C. Bull, geophysicist, also the full two years in Greenland, read their own papers. Dr. E. W. Hindle, F.R.S., took the chair at the meeting, which concluded with a discussion summarized on pp. 238–40. The papers which follow represent a much fuller version of the expedition's findings than it was possible to give at the meeting. A paper on the geology of the Britannia Sø area by J. D. Peacock (geologist in the first year) has been added. A map of north-east Dronning Louise Land on a scale of 1/50,000 is at the end of the *Journal*.

I. THE SURVEY OF DRONNING LOUISE LAND

LIEUTENANT F. R. BROOKE, R.N.

1. THE PLAN AND THE TERRAIN

The expedition surveyor, Captain Hans Jensen of the Danish Geodetic Institute, assisted by myself, had three tasks to fulfil:

a. To triangulate Dronning Louise Land in order to provide the ground control for a map to be made from oblique aerial photographs. This map together with all the survey data would be worked up by the Danish Geodetic Institute.

b. In the course of triangulating Dronning Louise Land, to determine the height of Krebs Bjerg, a peak in NW. Dronning Louise Land, with a maximum error of +/− 3 metres. This height was required for the starting point of a gravity survey across the inland ice.

c. To connect the Dronning Louise Land triangulation to the existing Danmark Expedition triangulation of eastern Dove Bugt.

Dronning Louise Land and the problems of travel.—Dronning Louise Land is a compact range of mountains about 100 miles north and south by 40 east and west. It is entirely isolated from the coastal mountains and from any other land by the ice sheet on the west and by two great glaciers, Storstrømmen and L. Bistrup Brae, which sweep round the land from north and south to a common outlet into Dove Bugt roughly opposite the mid-point of the eastern side of the land. These glaciers, though only about 20 miles wide, form a very considerable obstacle to travel. A high range of mountains, rising from 5000 feet in the north to 8000 feet in the south, lines the western edge of the land. The inland ice is also higher in the south than in the north and remains 1000 to 2000 feet lower than these mountains. In contrast to the mountainous and icy nature of the western half, the eastern half of the land is a country of

comparatively low rolling stony hills. Here again the land tends to be higher in the south than in the north. Although no one before us had stayed any length of time in this land, and the vast majority of it had never been seen from the ground, there was no actual geographical exploring to be done. In addition to air photographs, a good small scale map of the area from air photographs without ground control was available on sheet 18 in the U.S. series of World Aeronautical Charts (scale 1/1,000,000).

Three big glaciers divide the land transversely, the Admiralty with Britannia Sø as its continuation, the Borg, and the Budolfi. Despite the strong winds which habitually blow down them, these glaciers provide the main sledge routes into the land which, mountainous and snow bare, is usually impossible for sledging. Sometimes one can force a light sledge up a river bed or along a line of snow drifts, but generally overland sledging is out of the question. The tributary glaciers and lakes which link the three main glaciers provide a sledge route north and south within the land, but are generally difficult to traverse with anything but a light sledge owing to steep gradients. It is usually better to go up the glacier to the edge of the inland ice, travel north or south along it and turn down the next glacier, even though this may mean four or five times the sledging distance of the cross-country route. The changing seasons also limit sledge travel. In the autumn (September and October) the glaciers are bare, or almost bare of snow, the dogs find it extremely difficult to pull the sledges over the ice hummocks, and much of the work must be done by the men. It is quicker and easier to manpack.

The sun is below the horizon from November until mid-February. February and March are cold and stormy; surveying away from base during these months is very arduous, and even just plain travel is full of difficulties. In April the weather improves. It is in the short season from early April until the thaw starts in the first half of June that the surveyor, travelling by dog sledge, can do his work. At this time the weather is generally fine and settled, the atmosphere is clear, and the visibility is very good except where spoilt by mirage effects. Once the thaw sets in sledging is only possible on the higher level of the inland ice; the lower glaciers are intersected by rivers and patchy with morasses of soft wet snow. During the summer the surveyor turns to manpacking, and during the thaw the glaciers, lakes and rivers, which were his high road for sledge travel in spring, are now obstacles to be avoided. August and September are the best months for manpacking, for not until August are the glaciers a reasonable travelling route, but on this expedition all men were employed by the yearly air lift during the first half of the month. At this time of year there is no soft, fatiguing snow on glaciers or land, the ground is hard underfoot, the rivers are diminishing in size, soon to dry up or freeze, it is not yet too cold and the weather is still reasonable. When travelling by dog sledge one's movements are always severely curtailed by the limited type of terrain a sledge can traverse; on foot, one's movements are only limited by the availability of depots, for it is not practicable for untrained men to carry more than about ten days' food in addition to survey and camping gear.

When planning a season's triangulation work of such an area as Dronning Louise Land it is necessary to make as accurate an estimate as possible of the time required, allowing for such contingencies as proposed survey stations proving unsuitable and, of course, bad weather and travelling conditions. My method has been to plan on slow travelling times, allow two days for every station and throw in five to ten spare days in a season of one to two months. This has worked reasonably well in practice and I have always been a few days in hand on my time-table.

2. THE SURVEY

During the autumn of 1952 Jensen hoped to connect the existing Danmark Expedition triangulation to the proposed triangulation of Dronning Louise Land. He planned to travel with me to Dove Bugt from Young Sund in m.v. *Tottan* in late August, and then travelling on foot, to occupy some stations in north-western Dove

Bugt before walking over Storstrømmen back to base. Unfortunately owing to the *Tottan's* failure to reach Dove Bugt the autumn survey season was entirely wasted. Jensen and I did not reach base until December 1952. During the winter, astronomical observations were made at Britannia Sø. At the end of January marks were built on some of the surrounding hills and a scheme of local triangulation prepared. In mid-February a base line was measured on the bare ice of Britannia Sø and extended to cairns on either shore. In early March Jensen and I sledged across Storstrømmen to Dove Bugt to resume the autumn work. Now that we had a sledge and could travel over the sea ice we were not limited to the original stations selected for the autumn manpacking journey and by occupying a few more stations we could extend the Danmark Expedition's triangulation over the whole of Dove Bugt. Unfortunately, soon after we started Jensen slipped and fell to his death when descending a mountain near Kap Niels. I must pay a tribute to him, the most unselfish of companions, a man I am proud to have known and worked with.

Erskine came over from Britannia Sø to help me finish the survey which we were able to do in the course of the next month, visiting stations as far apart as the Danmark Expedition cairn on H. A. Jensen Bjerg in the north, the southernmost of the Braeoërnen ('Southern Brae Ø') in Borgfjorden in the west and Kap Alf Trolle, the southern tip of Store Koldewey in the south-east. In six weeks of actual surveying eleven triangulation and resection stations had been occupied in an area of about 2000 square miles. (Triangulation diagram of Dronning Louise Land faces p. 211.)

The whole of north-eastern Dronning Louise Land north of the Borgjökel was triangulated in autumn 1953. Erskine and I visited the seven stations remote from base during a manpacking journey from August 23 to September 24. During the following weeks the local stations were occupied, mainly with the assistance of Arnold. In October a new base line was measured on the lake ice of Britannia Sø and extended to the cairns on either shore, as a check on the base line which had been measured under very cold conditions in February. The base line was measured three times with a range of 0·25 metres. The difference in length of the extended base line, as measured in February and in October was 1·5 metres in 3517 metres. In view of the much better conditions in October when the work was completed in five hours as against eleven days in February, when errors must have been introduced owing to the movement of the lake ice, I have accepted the value for October.

Dronning Louise Land is entirely surrounded by ice and the nearest point at which mean sea level could be determined was in Borgfjorden. It was considered necessary to make simultaneous reciprocal observations between Dronning Louise Land and Borgfjorden (a ray of 29,718 yards) in order to minimize errors arising from abnormal refraction. These observations were made on April 13 at five-minute intervals on alternate faces between 1400 and 1455 G.M.T. inclusive. Jones and I occupied Gundahl Knold in Dronning Louise Land while Arnold and Moreton occupied the 'Southern Brae Ø.'

During the rest of the spring, travelling with Masterton, I triangulated the remainder of Dronning Louise Land, while Arnold and Moreton in the course of their glaciological journeys resected various points in northern Dronning Louise Land from the existing cairns. During that spring, in 2½ months of intermittent sledging and surveying, I occupied fifteen triangulation stations two of which I had also occupied the previous autumn. During the course of the survey work the triangulations of Dronning Louise Land and Dove Bugt have been connected—a little loosely perhaps, but as well as possible under the circumstances. Great difficulty was experienced in seeing some of the cairns at distances of 30 miles or more. In late June and July, Arnold and I fixed some 150 points of detail by theodolite resection in the neighbourhood of Britannia Sø to form the ground control for a large-scale map to be made from R.A.F. vertical photographs.

Further details of the triangulation.—In north-eastern Dronning Louise Land from Gundahl Knold in the south-east to Krebs Bjerg in the north-west all three angles in

the triangle were measured but in the remainder of Dronning Louise Land and throughout Dove Bugt only two angles in the triangle were measured. Measuring two angles only, though less accurate, is considerably quicker than measuring three. To measure three angles in the triangle every station, except one or two of those on the edge of the triangulation, must be visited twice, once to build a cairn or other mark and once to take the angles. When measuring only two angles in the triangle it is often possible to build a cairn on some central hill and then work round it in a semi-circle taking angles and building a cairn the same day on each station, finally returning to the central hill to take angles to the cairns that have been built around it. In difficult country it only takes about half the time to measure two angles in the triangle as it does to measure three. Throughout the work three rounds of angles on each face were taken to the other cairns, and two readings on each face for vertical angles though each reading was the mean of two settings of horizontal crosswire and bubble. The position of each triangulation station was pricked through on to the oblique aerial photographs. This has to be done "spot on" or the station is valueless as far as the air photographs are concerned. Occasionally it happens that the observer cannot recognize his own standpoint exactly. He must then make a plan in the field book and pace out or measure the distance and bearing of every prominent mark such as big stones, changes in colour of the ground or marked changes in slope within 100 yards and hope that these marks will be identifiable in the big plotting machines back in civilization and that, from them, the actual position of the station can be pinpointed.

In addition to the angles to cairns, angles were also taken to prominent points of detail that could be identified on the photographs. Owing to the rounded featureless nature of much of the country, natural marks were few and far between—especially so in Dronning Louise Land—and only in the extreme south-west of the land were there many natural marks. By and large, it was essential to build a cairn in order to identify a point properly. There was seldom any difficulty in finding loose stones for cairn building but this happy state of affairs probably does not exist in regions where there is a heavier precipitation. The chances of not being able to build a cairn were in fact so small that I left the tripod behind during the autumn manpacking journey and trusted to erecting the theodolite on a half-built cairn. The resulting centering error was no greater than when a cairn is built by eye over a station mark. This method proved so successful that I did the same the following spring. There is much to be said for it in windy weather when a cairn makes a far more stable foundation than any tripod.

The height of Krebs Bjerg.—All the survey computations are being worked out by the Danish Geodetic Institute. I have calculated the height of Krebs Bjerg (the starting point for the gravity survey across the inland ice) in order that the results of the gravity survey can be worked up. It will be remembered that in north-east Dronning Louise Land, between Gundahl Knold in the south-east and Krebs Bjerg in the north-west, all three angles in the triangle were measured. The average closing error of the twenty odd triangles in this area is between seven and eight seconds. All the vertical angles except at one station were done at the time of minimum refraction (1100–1500 local time—usually at 13–1400). When the vertical angles at each station had been meaned, they were corrected for height of signal and instrument. Then, using the formulae (1) to (7) given by Mr. H. F. Rainsford [1] in "Trigonometric Heights and Refraction," the difference in height and the coefficient of refraction were worked out for each reciprocal ray. The coefficient of refraction was remarkably consistent varying between 0·086 to 0·134 over Dronning Louise Land and from 0·131 to 0·163 between Dronning Louise Land and the 'Southern Brae Ø' over Storstrømmen—this despite the fact that on only two occasions were the rays truly reciprocal and in some cases one ray was taken in the autumn and its reciprocal

[1] I gladly take this opportunity of thanking Mr. Rainsford for much help and advice in calculating these heights. The paper referred to appears in *Empire Survey Review*, October 1955.

the following spring. In a few cases, only a non-reciprocal ray was available. In these cases the coefficient of refraction used was the mean value for the particular local area. The coefficient of refraction forms an invaluable check and if there is much inconsistency one immediately suspects errors in computation or booking. The results of the actual reciprocal observations between the 'Southern Brae Ø' and Gundahl Knold proved disappointing (see Appendix, page 209). The last two observations have been discarded since the refraction was altering visibly during these observations; even so, the difference in height varies from 567·1 to 571·7 feet and the coefficient of refraction from 0·134 to 0·163, any one of which might be the correct answer. The triangular misclosure of 'Folly'[1]–'Southern Brae Ø'–Gundahl Knold (using the mean of these reciprocals) is 7·5 feet which is of the same order as the misclosure of 8·1 foot for the triangle Rutherford Bjerg-Gultop-'Twincap' though admittedly this triangle has a non-reciprocal ray in it. So the 'Folly'–'Southern Brae Ø' ray was included in the final solution. These height differences were then adjusted by a least square solution. All lines were weighted inversely as their length and non-reciprocal rays were given one-third the weight of a reciprocal ray. This solution gives for Krebs Bjerg a height of 5357·8 feet with a standard error between the 'Southern Brae Ø' and Krebs Bjerg of 3·1 feet. The height datum is the surface of the sea ice in Borgfjorden in April 1953 when Erskine and I visited the 'Southern Brae Ø'; the height of the 'Southern Brae Ø' was found from reciprocal vertical angles to both ends of a short base on the sea ice. These gave for the 'Southern Brae Ø' heights of 221·4 feet and 221·2 feet or mean 221·3 feet.

Using the surface of the sea ice as datum is unsatisfactory but it was the best that could be done under the circumstances. There is very little tide in Dove Bugt and presumably even less in Borgfjorden protected as it is by the damping effect of a mass of islands, icebergs and fjords. Sea ice is normally about 6 feet thick in the spring so, as it floats with about one-eighth of its mass above water, we must assume the mean sea level is 0·75 feet below the surface of the sea ice.

3. METHODS AND EQUIPMENT

Cairns and flag markers.—Cairns and cairn building are an essential part of surveying in these regions. As expedition members, who have no previous knowledge of surveying or cairn building often help by building cairns, it is necessary to repeat what has already been said by M. Spender (see *Geogr. J.* **86**, 4, (1935) 325) in order that their labour may be used to the best advantage.

In order to see cairns at long distances, they must be tall enough to break the skyline and broad enough for the eye to see. Assuming the cairn is on the skyline, from a particular viewpoint it is the breadth that counts. In Dove Bugt most of the cairns built were a good 4 feet in diameter and about 7 to 8 feet high. This is by no means too big and they were not always visible at ranges of 23–35 nautical miles. The cairn on Kap Niels has been seen at a range of about 40 nautical miles. In Dronning Louise Land, where the rays were not usually more than 10 to 15 miles, we built smaller cairns 3 to 4 feet in diameter and 6 feet high. It is always advisable to build a cairn too big rather than too small. It is annoying to say the least when on a distant rounded hill you can see three projections, any one of which might be the cairn.

Cairns should be built systematically. Use large rectangular stones for the outside. When the first circular row is complete, fill in the middle with smaller stones. Then build up the outside row again taking care not to let the cairn slope in too quickly, and so on until the required height is reached. Finish off with a few big stones—the bigger the stones used throughout the building of the cairn the better. The length of time taken by two men to build a cairn of the dimensions mentioned above depends

[1] Names in quotation marks are not official and were given purely for the convenience of the survey.

largely on the availability of suitable rocks. A cairn of this size has been built in forty-five minutes, but more usually it takes one and a half to two hours. A stone that is apparently firmly embedded can often be loosened by dropping another heavy stone on it. It is very easy to strain one's back when cairn building. It happens when one least expects it and probably when lifting a stone well within one's strength. A strained back can put one out of action for anything from a week to the whole season, so it is worth taking care. The thing to remember when lifting stones is to take it slowly and never jerk.

In regard to flag markers, if the flag has a sky or glacier background, a dark colour (black) is best; but if it has a rock and/or snow background, yellow or orange is best. Red flags lose themselves in a rock background very easily. All coloured flags bleach very quickly in these conditions. (See below, page 214.)

Instruments.—The expedition was supplied with the following theodolites: Watts vernier reading to 1′; Tavistock micrometer reading to 1″; Zeiss T2 micrometer reading to 1″; Wild T2 micrometer reading to 1″.

The vernier theodolite was never used owing to the extreme inconvenience of using it in low temperatures compared with micrometer models. The Tavistocks were used by the ice sheet Weasel teams. They are too heavy (weight with case and tripod, 42 lbs.) for manpacking and unnecessarily so for dog sledging. The Zeiss was used for the astronomical observations and by the second survey team in spring 1954. The Wild was used for all the triangulation work done by Captain Jensen and myself and was quite the best theodolite we had for this work being reasonably light (weight 17 lbs. + tripod 7 lbs.) robust, easy to handle in the cold and easy to read.

However, the Zeiss and Wild did not appear to have been specially oiled for low temperatures and both became stiff below 0° F. The Watts and Tavistock theodolites which had been variously greased with Dow Corning Silicone Grease D.C. 33; Canadian National Research Council Oil and Grease; Aero shell Fluid No. 1 and Grease DTD 577 remained perfectly free down to −40° F. and the Tavistocks were used in temperatures of −65° F. The Wild and Zeiss theodolites were carried on a sledge in a sorbo-rubber lined ration box and despite rough going never came to any harm. An effort was made to place the box in the centre of the sledge.

The various screws of the theodolite should be made of bakelite. If they are metal, putting insulating tape round them helps to prevent the fingers getting cold in low temperatures. The Norwegian–British–Swedish Expedition to the Antarctic went one further than this and put large rubber discs over each screw so that once the theodolite was set up it could be manipulated in big gloves.

Clothing.—Clothing for the stationary work of surveying on a mountain top must be light and warm. Furs were worn in years gone by, but nowadays an eiderdown suit (jacket and trousers) filled with the best down with windproofs over the top is the best answer.

Neither the expedition boots or *mukluks* were warm enough for mountain top survey work in low temperatures. The boots were all right down to about 0° F. and the *mukluks* down to −15° F. This rather high minimum temperature was due to the inevitable sweating on the long walk up. Also *mukluks* are not good footwear for mountains and Captain Jensen's death can be partially attributed to the fact that he was wearing *mukluks*. For mountain top surveying a very warm mountain boot is required. The Norwegian–British–Swedish Expedition to the Antarctic wore ski boots very similar to ours, into which they managed to get so much insulation (socks, dogskin socks and duffels) that the frost line (the line where the vapour passing from the foot freezes) came within the insulation and not against the leather of the boot. The boot was therefore easy to dry. They found these boots quite satisfactory. But probably the best answer would be a boot made on the vapour barrier principle, similar to, but much stouter than the high altitude boots used on Everest, with perhaps an overboot to put on on the summit. Investigations on these lines are going on in England.

Everyone has their own ideas about gloves. I found two pairs of close-fitting woollen mitts, wristlets, and when necessary, a pair of windproof mitts made of light windproof cloth, perfectly satisfactory.

I found a windproof hat preferable to a balaclava with *anorak* hood up. The *anorak* hood frequently gets in the way when surveying. Under normally windy conditions surveying with this equipment is quite comfortable down to 0° F., but it becomes progressively more uncomfortable below that temperature. Changing clothes on the summit is apt to be the coldest part.

Composition of survey parties.—By force of circumstances survey teams were always composed of two men. This is quite sufficient unless an excessive amount of equipment must be carried to the mountain tops. Two men, however, do not form such a safe team as three or four men. This is especially the case when operating in badly crevassed areas. However, if the party is enlarged to more than two men, the additional men should have some other scientific interest such as geology. For surveying in the mountainous regions of the Arctic it is most important that of a party of two, one man should have experience of guideless climbing in the Alps or other glaciated ranges and the other man should at least be able to look after himself on the British hills in all seasons and weather. For preference, both men should be experienced mountaineers. In fact no triangulation stations in Dove Bugt or Dronning Louise Land were placed on difficult mountains. But had the topography of southern Dronning Louise Land been only slightly different, one or more difficult peaks in the south-west corner of the land would have had to be climbed. Surveying ability alone is no use unless the party can climb safely to its mountain stations and down again. In conclusion, I would like to thank all those who have come out and booked for me, or helped build cairns on cold windswept hilltops.

APPENDIX

Reciprocal Observation 'Southern Brae Ø' to Gundahl Knold

13/4/54

Vertical Angles corrected for height of instrument and signal

Time G.M.T.	*Gundahl Knold*	*to*	*'Southern Brae Ø'*	*'Southern Brae Ø'*	*to*	*Gundahl Knold*	*Diff. in ht. feet*	*K*
1405	−0 29		20·4	+0 19		45·0	567·1	0·134
1415	−0 29		09·4	+0 19		59·0	567·7	0·149
1425	−0 29		12·9	+0 20		07·75	570·0	0·153
1435	−0 29		08·9	+0 20		20·25	571·7	0·163
1445 *	−0 28		02·9	+0 20		49·25	564·6	0·224
1455 *	−0 28		05·4	+0 20		03·5	556·2	0·193

* Refraction was visibly altering during these times.

Mean without the last two 569·1 feet.

Reciprocal Observations H. A. Jensen Bjerg to Kap Bellevue

15/10/53

Vertical Angle corrected for height of instrument and signal

Time G.M.T.	*H. A. Jensen Bjerg to Kap Bellevue*		*Kap Bellevue to H. A. Jensen Bjerg*			*Diff. in ht. feet*	*K*
1405	−01 18	55·3	+01	11	44	1210·3	0·105
1415	−01 18	47·3	+01	11	49	1210·1	0·117
1425	−01 18	45·3	+01	11	57	1210·7	0·126

Mean 1210·4

II. GEOLOGY OF THE BRITANNIA SØ AREA, DRONNING LOUISE LAND

J. D. PEACOCK

The fieldwork on which this short account is based was carried out by P. J. Wyllie and the author at widely spaced intervals during the stay of the British North Greenland Expedition at Britannia Sø. With the publication of a topographical map of the area, it is now possible to locate many of the outcrops fairly accurately, and though the amount of information is small, there is a basis for a geological map. A general account of the geology of Dronning Louise Land is in the press.[1] Within the area of the map, three rock groups are represented. In the east are the northern representatives of the Eastern Schists and Gneisses, consisting in this area of semi-pelitic schists and gneisses together with subordinate amphibolite. Felspathised rocks occur at several localities, and pegmatitic intercalations, knots, and veins are common. Further west, the south shore of Britannia Sø and the eastern flank of the Britannia Gletscher are formed of the Britannia Sø Group, a series of quartzites and limestones, with some schists and a few bands of quartz-magnetite rock. The ground to the south of the Admiralty Gletscher is occupied by granitic gneisses and schists of uncertain relationship.

Regional detail

South-west of the junction of the Gultop and Admiralty Gletschers.—Within 400 or 500 metres of the glacier junction, coarse- to fine-grained felspathic augen-gneiss composed largely of microcline, acid plagioclase and quartz is exposed, together with bands of quartz-biotite-schist. On the low ground near the small ice-dammed lake, the dip is variable, but higher in the hillside the rocks dip at about 20 degrees to the south-east. There are concordant or slightly cross-cutting bands of dark biotite-schist which contain scattered red garnets. Higher in the hillside, the rocks appear to be similar, but traversed at intervals by bands of hornblende-quartz-schist of a type common further east. A yellowish rock outcropping in the precipice overlooking the Gultop Gletscher may be the continuation of the quartzite which forms the summit of Gultop.

Støvdal.—Glacial debris and outwash material obscures much of the solid geology, but bare rock surfaces are exposed at three points. Immediately east of the junction of the Gultop and Admiralty Gletschers the following succession can be seen:

Augen-gneiss with biotite-schist	
White quartzite and muscovite-schists	a few metres
Blocky red-stained quartzite	*c.* 20 metres
Dark quartzite and muscovite-schists	*c.* 50 metres
Massive fine-grained quartz-magnetite rock	*c.* 10 metres
Muscovite-schists	

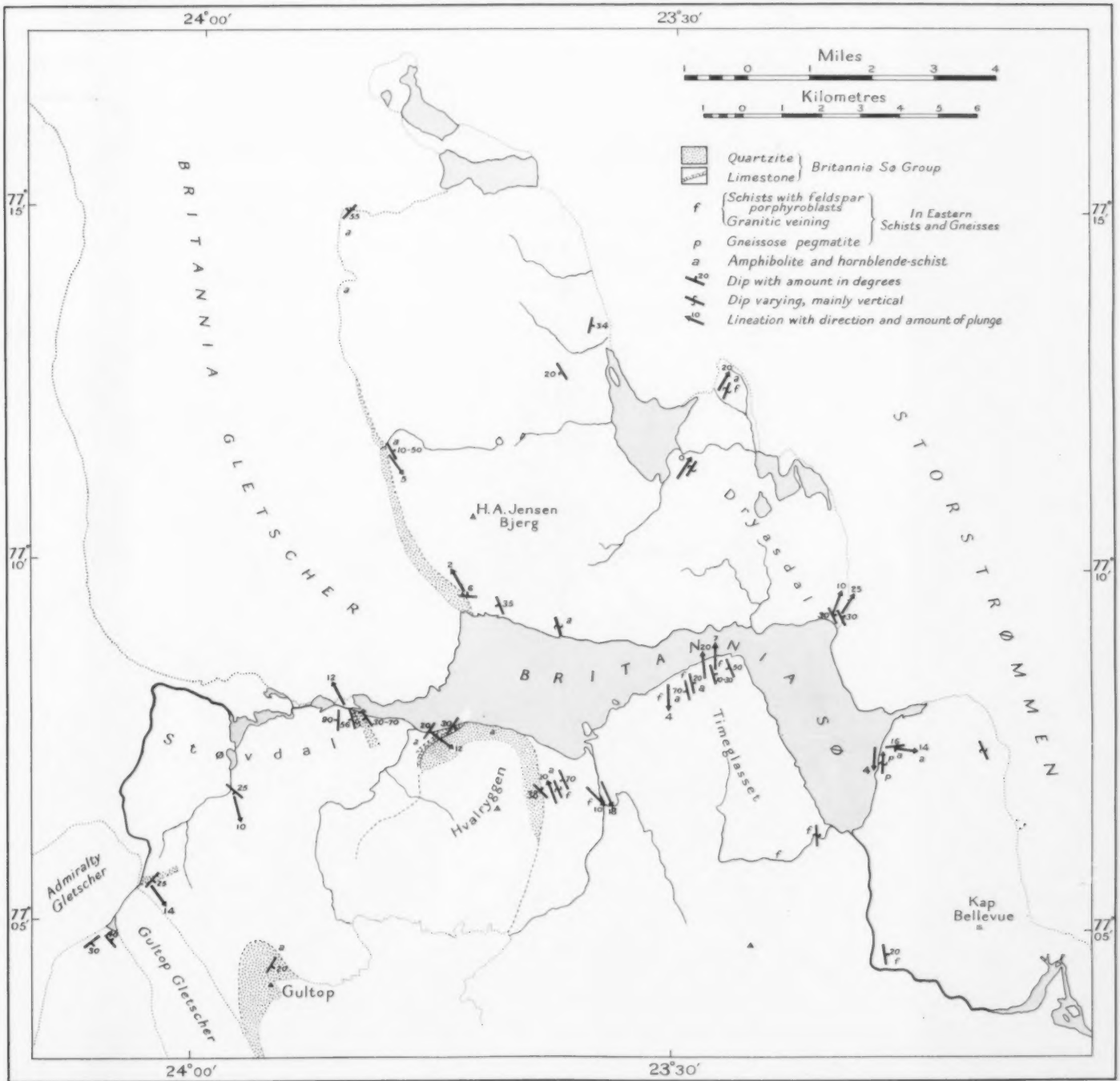
The outcrops are discontinuous, and disappear under scree and drift at either end. The dip varies somewhat, being generally about 25 degrees to the south-east. Current-bedding in the red-stained quartzite shows the succession to be inverted.

Apart from an isolated outcrop of limestone in the stream bank 3 kilometres north-east of the glacier junction, there are no further exposures on the low ground until the point at which the outflow from the Admiralty Gletscher discharges into Britannia Sø. Here there is a bare rocky surface with beds striking NNW. and dipping at between 60 and 90 degrees west. The approximate succession is as follows:

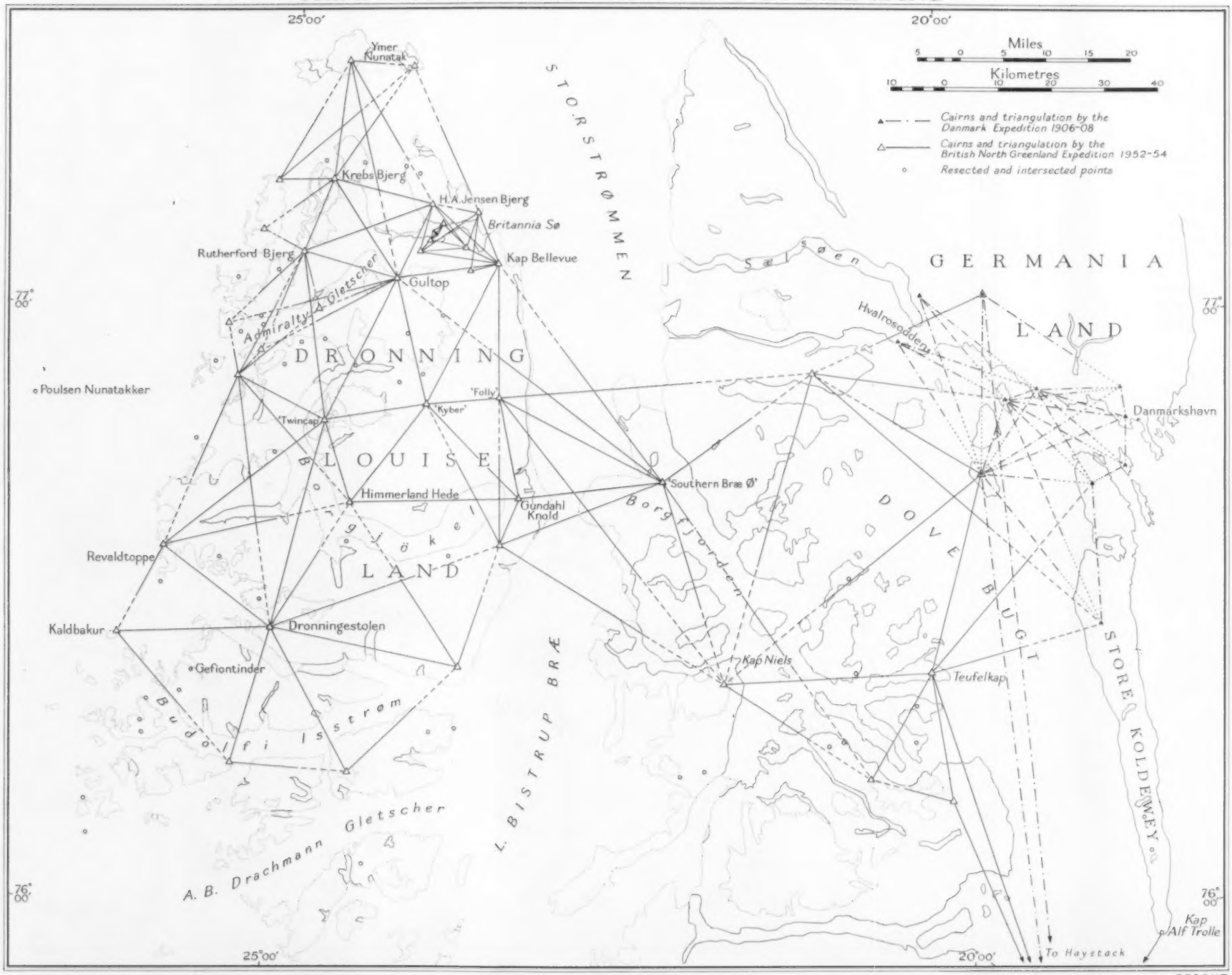
Blue-grey, white, and yellowish limestone	*c.* 150 metres
Red-stained quartzite, muscovite-schists, quartz-magnetite rock	*c.* 150 metres
White current-bedded quartzite	8 metres

[1] Peacock, J. D. (1956), "The geology of Dronning Louise Land, North-east Greenland." *Medd. Grønland*, **137**, 7 (in press).

NORTH-EAST DRONNING LOUISE LAND : BRITANNIA SØ AREA



TRIANGULATION OF DRONNING LOUISE LAND



BROOKE

The current-bedding in the white quartzite faces towards the west, and therefore the succession is uninverted. The red-stained quartzites and muscovitic quartz-schists form the majority of the overlying beds, with isolated bands of quartz-magnetite rock up to half a metre thick. Near the junction with the limestones there is a thin development of calc-schist. Both the schists and the limestones above are highly contorted, and the thicknesses given are calculated only on width of outcrop.

Hvalryggen.—On the south shore of Britannia Sø, about half a kilometre east of the resection point "315" (see map, end of *Journal*) there are the following exposures:

Creamy limestones with calcite veins	*c.* 33 metres
Red-stained quartzite with thin bands and lenses of quartz-magnetic rock Grey-banded quartzites and muscovitic schists	*c.* 120 to 130 metres
Biotite-chlorite-schists with quartz veins	*c.* 10 metres
Amphibolite	*c.* 50 metres

These rocks dip at between 20 and 30 degrees to the ESE., and current-bedding in the grey quartzite indicates that the succession is the right way up.

East of this point the outcrops continue, but the succession is ambiguous. Above the limestone there is another red-stained quartzite, much sheared, in which some of the current-bedding is inverted. The red-staining is considerably reduced in thickness southwards along the strike, but it is not clear whether this is due to folding or simply reduction in the amount of staining. A thin limestone follows, and then outcrops of quartzite showing evidence of tight folding continue east of triangulation point "230." The apparent dip of these thick quartzite outcrops is towards the east at varying angles. Not far from triangulation point "230" there is an irregular body of hornblende-quartz-epidote-schist showing intrusive relationships to the quartzites. Light-coloured rocks, probably quartzite, form the summit of Hvalryggen, and are visible at intervals through the extensive scree cover of the mountains to the south-west. The summit of Gultop is formed of yellowish-weathering white lineated quartzite, below which is a scree of hornblende-quartz-schist and augen-gneiss. The rocks on this latter peak are tilted gently south-east.

Timeglasset.—The highly siliceous rocks encountered on Hvalryggen are followed rather abruptly eastwards by schists and gneisses belonging to the Eastern Schists and Gneisses. These underlie much of the debris-covered ground between Hvalryggen and Timeglasset. On the hillside to the west of the river there are sporadic outcrops of quartz-mica-schists and quartz-oligoclase-microcline-biotite-gneiss, the latter veined with a granitic rock and traversed by concordant sills of hornblende-quartz-schist. The relationship of these rocks to the quartzites is not seen, but there is not evidence of any discordance. In the valley bottom, a small section of similar gneisses with thicker granitic bands is exposed. Here there are pegmatitic quartz-feldspar veins present, and porphyroblastic feldspars are developed in the gneisses. The strike throughout is NNW. and linear structures due to small-scale folding and alignment of minerals plunge gently SSE.

Near the lake shore on the north side of Timeglasset, there are more exposures of rocks which resemble those described above. In addition there are dark and light banded gneisses composed of varying proportions of quartz, oligoclase, biotite, epidote and hornblende, and a bed of quartzite outcrops at one point. There are a number of bands of biotite-hornblende-schist and hornblende-quartz-schist which are concordant generally, but sometimes discordant in detail. Porphyroblastic schists are frequent, the individual augen being largely single crystals or clumps of microcline, but antiperthitic oligoclase is sometimes present. Some of the granitic bands, which are concordant with the other rocks are formed obviously by coalescence of pink feldspar augen: the larger bands may be several metres in thickness, but often the felspathic material occurs as intercalated lenticles and streaks in the schists. At

intervals all rocks excepting the hornblendic schists are cut by veins of pegmatitic pink or white feldspar and quartz. As before, many of these rocks are strongly folded on a small scale, and strike NNW., with a lineation plunging gently either north or south. On a somewhat larger scale, the structural picture is of small folds with gently-dipping east limbs, and steep or overturned west limbs.

On the east side of Timeglasset and as far south as the right-angle bend in the outflow from Britannia Sø, the variegated schists and gneisses with pegmatitic and granitic veins, and feldspar eyes are exposed at intervals from beneath the drift cover or scree. There is little to differentiate them from those described above excepting possibly the more frequent occurrence of visible red garnet, and the even-grained appearance of some of the granitic material.

Kap Bellevue area.—From the point of view of this description, the Kap Bellevue area refers to all land lying east of the outflow from Britannia Sø. The fieldwork here was restricted to one traverse across the northern, more low-lying part of the hill. About 1 kilometre south of the glacier flowing westwards into Britannia Sø, there are a number of hillside exposures of quartz-biotite-schist with muscovite and a little feldspar in places. The more siliceous bands contain a sprinkling of almandine garnet. Intercalated with the schists are bands up to 1 metre thick of white gneissose pegmatite composed of quartz, oligoclase, microcline, muscovite, and garnets up to 1½ centimetres across. The contact of the pegmatites with the schists or their gneissic relatives is transgressive in detail, and at one point is marked by feldspar augen in the neighbouring rock. The dip is variable due to the minor folding, which together with the corrugations in the schists, gives a well-developed lineation which plunges very gently south. About 1 kilometre from the shore of the lake, there are outcrops of fairly uniform coarse feldspathic schists, pink weathering, with concordant veins of pegmatitic grey feldspar and quartz. Allied to this material is a body of crudely foliated granite gneiss, highly folded, about 50 metres across. It is composed of microcline, quartz, oligoclase, and biotite, and is set through with aplitic veins of the same minerals. In this region too there are numerous concordant bands of coarse-grained hornblende-biotite-quartz-schists, and a body of muscovite-bearing pegmatite with crystals up to 15 centimetres across. Overlooking Storstrømmen are outcrops of highly folded quartz-biotite-, and biotite-quartz-gneisses, with small red garnets in more siliceous bands.

Dryasdal.—The hill overlooking the eastern part of Britannia Sø is formed of variegated schists and gneisses composed of quartz and biotite, with varying quantities of muscovite and feldspar. Apart from a linear structure due to the folding on NNW. lines, which is here not so intense as on Kap Bellevue, a second lineation plunges about 30 degrees north-east. Northwards, an isolated exposure emerging from the drift between Dryasdal and the southernmost extremity of the largest lake is made up of biotite-quartz-schists folded on north-easterly lines. This changed strike direction is continued at the resection point "414" east of the northern end of the large lake. Here there are exposures of garnetiferous hornblende-gneiss with concordant bands of granitic material.

Area north-east of H. A. Jensen Bjerg.—West of Dryasdal the solid rock is largely covered by glacial debris, and outcrops are scanty east of a line running north from H. A. Jensen Bjerg. There are sufficient exposures, however, to infer that the area is underlain by quartz-biotite-schists which contain varying quantities of feldspar, and sometimes garnet and magnetite. Grey and white feldspar pegmatites occur as knots, lenticles, and sometimes in thicker bands. Porphyroblastic schists and granitic veining seem to be absent.

Area west of H. A. Jensen Bjerg.—In the waterfall marked north-west of H. A. Jensen Bjerg, quartzites of the Britannia Sø Group outcrop and can be traced south-eastwards to a short distance east of the snout of the Britannia Gletscher. At the waterfall, the succession is as follows:

White quartzites, quartz-schists, hornblende-schists	
Red-stained quartzite	*c.* 150 metres
Muscovite-schist and white quartzite	*c.* 70 metres
Quartzite with magnetite	*c.* 1 metre
Red-stained quartzite, base not seen	

The uppermost beds in this succession contain veins and irregular bodies of white feldspar, and pass upwards into schists containing quartz, biotite, muscovite and feldspar in varying quantities. These variegated schists evidently belong to the Eastern Schists and Gneisses. The quartzites show traces of current-bedding which is not well enough preserved to be used as a top and bottom criterion.

About 4 kilometres north of the waterfall, various patches of dark scree are derived from hornblende-quartz-schists which are intercalated with highly folded muscovite-bearing quartz-biotite-feldspar-gneiss. The most north-westerly exposure is formed of white quartzite and quartz-schists, which may be the same beds as those outcropping above the waterfall. The strike of the beds at the waterfall is NNW., and the beds dip at varying angles to the east. Further north there are some north-easterly strikes, but the dip in the schists is very variable.

Conclusions

From the evidence presented above, certain limited conclusions can be drawn. The Eastern Schists and Gneisses are conformable with the Britannia Sø Group and seem to follow it in normal order of succession, as may be inferred from the section at the waterfall north-west of H. A. Jensen Bjerg. A similar state of affairs seems to exist east of Hvalryggen, though current-bedding evidence confirming the order of succession of the Hvalryggen quartzites is lacking at present. However, this interpretation fits with indirect evidence from other parts of Dronning Louise Land, where quartzites resembling those at Britannia Sø, and perhaps equating with them, outcrop near the western boundary of the largely easterly-dipping schists. Following from this, the quartzites outcropping east of the Britannia Gletscher must be continuous with those building Hvalryggen and the mountains to the south-west. With the available information, it is not possible to elucidate the structure in Støvdal and the area to the south, though there are some tantalizing resemblances between local successions. Detailed mapping based on the new topographical map will probably solve many of the structural problems of this interesting region.

Acknowledgements

The author is indebted to Mr. P. J. Wyllie of St. Andrew's University for information additional to personal or joint field notes, and to Professor T. S. Westoll of King's College, Newcastle, for editing the manuscript.

III. MAP OF NORTH-EAST DRONNING LOUISE LAND 1/50,000

1. CONSTRUCTION FROM VERTICAL AIR PHOTOGRAPHY

K. ARNOLD

In December 1953, during the second winter, it became evident that a topographic map of the area immediately surrounding the expedition's main base would be of great value in writing up scientific reports. Especially would this be so for the glaciologists and geologists in their studies of glacier retreat and interpretation of moraines and terraces around Britannia Sø. It would also assist the geophysicist in computing and plotting gravity observations taken on the frozen surface of Britannia

Sø the previous winter. Such a map would be required on a scale of 1/50,000 or larger, and would be contoured.

The area to be mapped was about 300 square miles. A large part of this, however, was glacier, with little detail. But because of the other commitments of the expedition surveyors, it was clearly impossible to map the whole area from the ground in the six weeks available, from the end of the sledging season in mid-June to the beginning of the evacuation in August. It was decided, therefore, to attempt the production of the map from air photography, controlled and supplemented by such ground survey as could be carried out in the time available. The Royal Air Force agreed to take the necessary photographs from one of the Sunderland flying boats to be used in the evacuation of the expedition the following August. Details of the camera to be used, and the flying height of the aircraft when taking the photographs were sent, and from these it was possible to plan the best use of the six weeks available.

It was not known by what method the map was to be produced from the air photography at the time that the ground control was planned, so an attempt was made to fix enough points of detail both in plan and height to allow three to be identified on each photograph, over the area not actually covered by ice or water. The glaciers formed such a confused pattern with their many river channels that it was quite unlikely that any features fixed here could be afterwards identified on the photographs.

The lowest ground in the area was about 500 feet, and the highest 4500 feet above sea level. Except in the south-west of the area to be mapped, the country was charaterized by flat-topped hills, falling steeply to the valleys running into Britannia Sø. The fact that the ground control had to precede the photography was a disadvantage, for it was difficult to decide which features of detail would be most easily identifiable from the air. Moraines, terraces, rock outcrops, patches of vegetation, bends in streams, differences in the colour of rocks or the edges of lakes were features that might easily be identified, but a fresh fall of snow might greatly alter their appearance.

Some control was already available in the area, in the cairns already built and observed during the main triangulation of Dronning Louise Land. With only two exceptions, these cairns were on fairly flat and featureless hilltops, and were not likely to show up in the photographs. In an attempt to make these cairns more obvious from the air, parachutes were cut up into the shape of a Maltese Cross, laid around the cairn and weighted down with stones. The overall size of these marks was about 30 feet in diameter, which on the scale of the photographs over these hills gave a feature of about 0·015 inches in size, but which could in fact be readily identified under a magnifying stereoscope. Altogether eight such cairns were marked, of which six were afterwards easily identified. Of the two that were not, one was lost in a fresh fall of snow, and the other, near lake level, was lost in a shadow cast by a cliff close by.

One difficulty was that only red parachutes were at hand. Those laid out first had bleached, and showed up the best. However, as long as there is sufficient colour contrast, a distinctive shape is the best way of identification. A wholly white colour may lead to confusion with patches of snow.

In addition to these points already fixed and marked, if approximately three points were to appear on every photograph, another 150 new points of detail would be needed. The most convenient method of fixing these features was to obtain a view over part of the country from some vantage point, and having chosen likely features, to visit each in turn, make a sketch of the immediate surroundings, and take a round of angles for resection. The flat-topped nature of the hills gave no view from the valleys of the cairns already built, and a number of new cairns had to be built on the edges of these hills. When such a cairn was built, two rounds of angles on each face of the theodolite were taken. When no other feature depended on the one being fixed, only one round was taken. In every case at least four cairns were chosen from which to resect the feature. This served as a check on the observations, and as some precaution against obtaining a circular fix.

The country was not ideal for travel on foot, as the ground is badly broken up by

frost action, and at this time there was a lot of marshy ground after the thaw. An average of about four to six points would be fixed each day, depending both on the nature of the ground, and on the number of cairns to be built. Some days were entirely devoted to moving camp from one area to another. This work was carried out from June 15 to the end of July 1954.

On return home this control was plotted. All the resected cairns and some of the features were computed by semigraphic resection, but those features which fell in a very favourable position for resection were plotted by station pointer on a scale of 1/10,000, and their coordinates then read off. All the features were eventually plotted on this scale to enable distances to be scaled off between features when the vertical control was worked out. This was done on three times the scale of the map drawings, and five times the scale of the finished map. The method of resection was quite adequate for fixing the new points, and in only four cases did a check ray indicate that the position was in doubt to a greater extent than the plottable error on the 1/30,000 drawing. However, the danger of a circular fix was not avoided in three instances.

After the best cover from the photographs was chosen, it was decided to provide control in plan by using a slotted template assembly. This had the advantage of providing a measure of control over the large areas of glacier where no points of detail had been fixed. The photographs were baselined and tie points chosen to join the strips of photography together. It was easily possible to identify common points on adjacent photographs over land and also over the glaciers. During the summer there is a fine network of streams and small lakes on the glaciers. If there are extensive areas of glacier featuring in any area to be photographed, it would appear to be an advantage to take the photography during the late summer or early autumn, after the obscuring blanket of snow has melted.

The slotted template assembly was controlled mainly by the principal cairns that had been marked by the parachutes, as these positions had the highest order of accuracy. One or two of the resected cairns were also used, but were only chosen if they could be identified exactly. When the assembly was laid down, it was remarkably firm over the areas of glacier where no control had been observed in the field.

The control from the slotted template assembly was transferred to a sheet of astrofoil, upon which the map was drawn. The detail on the photographs was marked up in poster colour, and transferred to the astrofoil with the aid of a Grant epidiascope. The essentials of this instrument are a transparent table to take the astrofoil, and a brightly illuminated holder for the photographs, that can be racked up and down and tilted in two directions. A lens projects the image of the photograph upon the astrofoil, and by tilting and moving the photograph up and down, it can be brought to the drawing scale, and the slotted template assembly points on the photograph can be made nearly to fit the corresponding points on the astrofoil. This does not allow for differences in heights between the control points; but by working with only three control points at a time, detail from the photograph can, after a little practice, be quickly and quite accurately transferred to the drawing material. This was checked by raying in points of detail in areas where there were great differences in height between the control points, and the discrepancy was nowhere greater than a millimetre at the 1/30,000 scale. These discrepancies would only be found in areas where there is rapid change of relief.

The identification of the 150 features fixed in the field was rather difficult, but after the detail had been transferred to the astrofoil, the astrofoil could be used in conjunction with the photographs to find the approximate position of the feature, and to draw a small circle around it. Afterwards it was possible to identify it more accurately with the aid of the stereoscope, and field sketches. Only eight features could not eventually be identified sufficiently accurately. Rock outcrops and the edges of lakes gave the least difficulty, but where reliance had been placed on differences in colour, patches of vegetation, and hummocks of moraine or terrace edges, more

difficulty was experienced. Even bends in streams are not as easy to identify from air photos as one would have supposed on the ground.

After the identification of these points, their heights were computed and marked on the photographs. Working with the aid of the stereoscope, form lines were drawn on the photographs between these points of known height, and transferred to the astrofoil from the photographs. It was only necessary to ray in the form lines when they were very open. Over the glaciers where there was no height control, no attempt was made to extrapolate the form lines, as in general the slopes are so gradual that such an attempt would be highly inaccurate. Over those areas with height control, the form lines are considered to be at least as accurate as anything produced by any plane table survey that might have been made of this area, had time in the field permitted.

The time spent in the field was about six weeks, and the time spent working up the results about six months. It would certainly have been much longer had it not been for the generous assistance forthcoming from the Directorate of Colonial Surveys, where the greater part of the work at home was done. All thanks are due for the insight given into the techniques of mapping from air photography at the beginning of the working-up of the map, and for the continuous friendly criticism and practical help given until the task was completed.

2. GREENLAND BY CAMERA

FLIGHT-LIEUTENANT S. BOWATER, D.F.C., A.F.C., R.A.F.

In August 1954 No. 230 Squadron of Royal Air Force, Coastal Command, was given the task of evacuating the British North Greenland Expedition from their base at Britannia Sø. A considerable proportion of the expedition's scientific observations had been made in the immediate vicinity of Britannia Sø and a requirement was put forward for a photographic cover to be made of the local area so that an accurate map could be made. This task would normally have been carried out by aircraft of a Photographic Reconnaissance Unit, but the absence of airfields within reasonable range of Britannia Sø made this impossible. Therefore there was no alternative but to carry out the photography using the Squadron's Sunderland flying boats.

The Sunderland is most unsuitable for this type of work. It is not fitted with oxygen and therefore is limited to a maximum altitude of 3000 metres; this makes vertical photography more difficult and tedious especially in mountainous country. There is no heating in the aircraft and 3000 metres above the Greenland ice cap can be a trifle chilly! Finally there is no position in the aircraft from which the aircraft can be tracked over a landmark and an accurate "on top" given. Apart from the unsuitability of the aircraft, the crews were totally inexperienced in this type of work and had to start from scratch developing their own techniques. In addition, the terrain around Britannia Sø is barren and featureless so that it was practically impossible to position the aircraft by reference to landmarks. It was estimated that the flight would take from eight to ten hours which would mean a safe petrol load of some 2000 gallons and judging from the experience gained in the previous years this would probably have to be pumped into the aircraft by hand! The only factor which appeared to be in favour was, by way of a change, the weather, which is usually ideal for photography with clear skies, little wind and unlimited visibility.

Preparations were started early in 1954. Cameras, mountings, magazines, heating muffs and special lenses were put on demand. In addition extra clothing was asked for although in fact the normal R.A.F. arctic clothing proved adequate. Two crews began training immediately and many sorties were flown during the spring and summer; finally a technique was evolved which after several tests indicated that it would prove successful in Greenland. The technique demanded a high degree of crew cooperation, but when the crews left for the Arctic every man knew his job to the last

detail. The plan of campaign was that the two crews would proceed to Greenland ahead of the remainder of the Squadron and carry out the photography before the ice melted on Britannia Sø. It was planned to photograph the area four times in all to minimize risks of failure. A special aircraft was to fly up to the base at Young Sund about four days later and return the exposed magazines to the United Kingdom for processing. The results were to be signalled to Young Sund so that any failures could be photographed again.

The two aircraft arrived at their Greenland base, Young Sund, on schedule on August 1. A reconnaissance of Britannia Sø on the following day proved that the lake was already ice free so it was decided that one aircraft would concentrate upon the more important task of evacuating the expedition leaving the second aircraft to carry on with the photography. Because of the tremendous amount of work required at Young Sund in organizing the camp it was possible to carry out only two photographic sorties before the aircraft arrived to take back the magazines.

The first sortie was flown on August 4 and lasted nine hours. The sky was clear of cloud apart from the usual lenticular formations characteristic of standing waves. These are a feature of this coast as the air flowing down the sides of the inland ice bounces off the coastal mountains. The temperature at 3000 metres was −10° C. and the sun warmed the cockpit comfortably although the rest of the aircraft was cold and there was a certain amount of ice around the camera. The scenery along the Greenland coast is impressive at any time but at 3000 metres it is awe-inspiring. To the west the bleak inland ice stretches away into a white infinity, while below the coastal mountains stand as a huge containing barrier and through them the ice grinds its inexorable way in the frozen torrents of the glaciers. The first sortie passed off without incident and appeared to have been successful. The second sortie was flown on August 5. The weather was once more excellent and for the first three hours everything went according to plan. Whilst on one of the photographic runs, however, the pilot noticed that although he was maintaining a steady heading on his compass he was in actual fact doing a very slight turn to port. Further investigation proved that in the south-western corner of the area lay an area of intense magnetic disturbance. Fortunately the effect only prevailed up to a distance of about 10 miles but it created a change of variation of no less than 10°! The phenomenon was eventually overcome by steering by means of the directional gyro. This had to be reset to the magnetic compass at frequent intervals outside the area of magnetic disturbance. The photography had to start from the beginning once more and the whole sortie lasted eleven hours.

On return to Young Sund from the second sortie an aircraft was waiting to return to the U.K. with the magazines. They were on their way within a few hours and after a short stop for fuel at Reykjavik they were landed at Pembroke Dock. Each magazine contained 120 feet of film and since the facilities for developing film at Pembroke Dock were inadequate for developing this length of film, arrangements were made for the film to be processed at R.A.F. Wyton. The Sunderland aircraft with four magazines arrived at Pembroke Dock at 1700 hours on August 6, the magazines were conveyed by road to Haverford West where an Anson aircraft was waiting to carry them to Wyton. The Anson touched down at Wyton at 1900 hours and within minutes the films were in the hands of the processors who were standing by to receive them. The work of developing the films and producing a thousand prints was completed by 2300 hours. It was then necessary to plot accurately the area covered by each photograph to ensure that complete photographic cover of the required area had been obtained. This task was completed at 0100 hours on the following morning and as soon as wireless contact was established with Young Sund the result was passed to the Squadron Commander.

As a postscript to the story it may be of interest to mention a few of the technical details and explain the technique which was used. The camera equipment consisted of an F.24 camera mounted in a vertical mounting and fitted with a $3\frac{1}{4}$-inch lens.

The camera was heated and was controlled by means of a type 35 control box. Magazines were of 250 exposure capacity. The area photographed was bounded by parallels 77° 05′ N. and 77° 19′ N. and meridians 23° 15′ W. and 24° 35′ W. It was approximately rectangular in shape centred on Britannia Sø and stretched approximately 26 kilometres north to south and 34 kilometres east to west. The height of the ground varied from 200 metres above sea level in the south-east corner to over 1200 metres along the western edge. To achieve a successful cover it is necessary to fly along a series of straight parallel tracks which are evenly and accurately spaced and which cover the area. Photographs are taken at regular intervals as the aircraft flies along each track. To ensure that the tracks are straight and parallel depends to the greatest extent upon the pilot's flying a steady and accurate heading on his compass. In more civilized areas he may be assisted by another crew member directing him over a series of landmarks or by radar but of course neither of these were practicable at Britannia Sø on account of the featureless nature of the terrain and absence of radar cover. It was decided therefore that sole reliance would be placed upon steering a steady heading on the distant-reading compass. This system was quite successful in the trials which were carried out in the United Kingdom but, as has been explained, it proved a dismal failure in the weak, irregular magnetic field around Britannia Sø.

The problem of achieving accurate track spacing proved difficult and caused a certain amount of head scratching. The obvious method would be to choose a landmark at the beginning of each track and direct the aircraft over it. This was not possible for two reasons—the landmarks were not available, and there is no position in a Sunderland aircraft from which it can be directed accurately over a landmark. This especially applies when flying at height. It was finally decided to use the ground postion indicator (G.P.I.). This is a device which as its title implies indicates the position of the aircraft relative to the ground. The aircraft's course and speed are fed in automatically and the wind velocity is fed in manually by the navigator. A small lighted arrow is projected on to the map or chart and indicates the aircraft's position and heading. It may appear that it would be a simple matter to direct the aircraft along the desired tracks by simply causing the arrow to move along the lines drawn on the map. Unfortunately the equipment is subject to certain errors which increases with time and are considerably increased when the aircraft is turned, therefore it was essential that the G.P.I. should be used as little as possible. It was also desirable that any turns that were made using the G.P.I. should be in the same direction and of the same duration. The system finally adopted was that the aircraft would start each run from a landmark off one corner of the area flying parallel to the side of the area. The G.P.I. was started as the aircraft passed the landmark and the aircraft was directed to turn 90° on to each track in turn. As soon as the aircraft was correctly on track the pilot would concentrate on flying a steady heading and as the aircraft approached the edge of the area the camera was switched on. The problem of starting accurately from the same point every time was overcome by designing a special sighting device. The device had a line of sight from vertically below the aircraft to approximately 10° out on either beam. Therefore if the aircraft passed over the landmark on a heading offset 90° from its photographic run, the fact that the G.P.I. was started when the landmark was on the beam would make no difference to the track spacing. The time between exposures is calculated beforehand and is then controlled automatically.

The method of wind finding used would probably be frowned upon by the navigation experts but seemed to work out remarkably well. It was decided that the taking of drifts and use of the wind finding attachment would be too inaccurate at 3000 metres. A five or six minute circuit was flown crossing twice over a landmark on a heading of north or south and the G.P.I. was started and then stopped as the landmark came on to the beam for the first and second times. The difference in air position was then measured on the G.P.I. chart and the speed of the north/south component of the wind velocity was calculated. A circuit on east or westerly heading

providing the east/west component and the resultant wind velocity was plotted off. Naturally no wind was set on the G.P.I. which became in effect an air position indicator.

The photography of Britannia Sø proved a most interesting task and from the very start it provided the aircrews with many entertaining problems which were gradually overcome one by one. It provided a welcome diversion from the relative monotony of normal squadron training. Finally after months of training, when the crews found themselves climbing into the clear blue skies over Britannia Sø they saw a landscape of such breathtaking splendour that it will remain in their memories for the rest of their lives. It was feared that the crews might suffer ill-effects from the prolonged exposure to the low temperature and altitude but this was not so. The man with the most thankless task was undoubtedly the second navigator who spent most of his time by the open camera hatch either using the sight or adjusting the camera. In spite of the enormous quantity of arctic clothing he was wearing he had to be brought into the galley at regular intervals in order that he might be thawed out with hot soup. On one occasion it became obvious to other crew members that the cold and shortage of oxygen were having some effect upon him, but fortunately he recovered before the sortie had to be abandoned.

After the magazines were despatched from Young Sund the weather began to deteriorate. Several anxious days were spent awaiting the signal announcing the results. The evacuation of Britannia Sø was almost complete and the pack ice at Young Sund was menacing the aircraft, making an early departure imperative. Therefore there was a mixed feeling of both satisfaction and relief when the signal was received indicating that success had been achieved.

IV. SEISMIC INVESTIGATIONS ON THE NORTHERN PART OF THE GREENLAND ICE-SHEET

C. BULL

One of the main parts of the scientific programme of the British North Greenland Expedition (1952–54) was the determination, by seismic methods, of the thickness of the inland ice in the northern half of Greenland. In the summers of 1949, 1950 and 1951, members of the Expéditions Polaires Françaises (E.P.F.) made seismic investigations on the southern half of the ice sheet and were successful in determining the ice thickness at some 400 points distributed over the area south of lat. 74° N., but when the B.N.G.E. left this country no seismic experiments had been made on the northern part of the ice sheet. In the summer of 1952 a party from Expéditions Polaires Françaises, working with the United States Army authorities, made some seismic experiments on a traverse running north-west from Thule across the inland ice towards the head of Independence Fiord, and in 1953 an American party carried out geophysical investigations on a traverse eastwards from Thule to the centre of northern Greenland. Unfortunately the results of these two sets of investigations are not yet available for incorporating with the B.N.G.E. results.

The results of the work in southern Greenland have been summarized in an earlier issue of this *Journal* [1] and elsewhere.[2] Their main feature is that over considerable areas of the central part of the ice sheet, the altitude of the bed rock is near sea level, so that the thickness of the ice is as much as 3400 metres.

The seismic method of determining ice thicknesses.—The method of measuring ice thicknesses which has been used with success in Greenland and on the Antarctic

[1] Holtzscherer, J. J., and G. de Q. Robin, *Geogr. J.*, **120** (1954) 193–202.

[2] Holtzscherer, J. J., and A. Bauer, 'Contribution à la Connaissance de l'Inlandsis du Groenland.' Expéditions Polaires Françaises, Paris, 1954.

continent is the seismic reflection method. In this, seismic waves are produced by the explosion of a small charge near the surface of the ice. Many types of waves are generated by such an explosion but in the following, attention is confined to the longitudinal or P waves, and not to the shear waves and surface waves which have lower velocities. Spreading from the point of explosion, the waves travel through the ice with a velocity which can be determined. The waves may be reflected at an interface between the ice and any other medium, providing that the boundary is sharp compared with the wave-length of the seismic wave and that the acoustical impedances of the media on either side of the boundary are different. This point will be considered at greater length later. Thus part of the seismic energy may be reflected at the boundary between ice and bedrock and return to the surface, where it can be detected with geophones.

The velocity of the seismic wave in the surface layers of the firn can be determined from the travel time of that part of the wave which travels direct from the shot point to the geophone. However, the velocity of the longitudinal wave, which is given by $V=\sqrt{\frac{k+4/3n}{\rho}}$ (where k is the compressibility, n the rigidity and ρ the density of the medium) varies considerably with depth, especially in the top 100 metres of the firn.

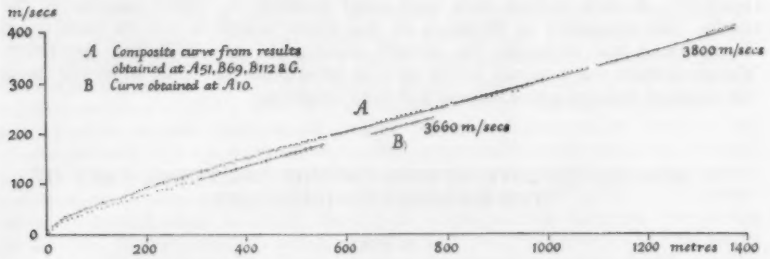


Fig. 1. Time-distance curves for P waves in two areas of the inland ice

Below about 150 metres the velocity remains almost constant, the increase in velocity due to increasing rigidity being compensated by the decrease in velocity due to increasing temperature.

In Figure 1 are shown curves obtained at two points on the inland ice of the variation of travel time of P waves with the distance between shot-point and detector. The differences in the maximum velocities of P waves at these points is mainly due to the different temperatures of the ice, but it can be seen that since the value of the maximum velocity does vary, the value used in calculating ice thicknesses from the travel time of reflected waves must be that obtained locally.

In the various sets of experiments different techniques have been used. In southern Greenland the French usually fired their charges near the surface. Above the firn line the low-velocity surface waves die out rapidly and it was possible to place the geophones about 500 metres from the shot-point, so that the reflected waves arrived in a quiet part of the record after the arrival of the direct longitudinal and shear waves. Below the firn line the surface waves persist for long periods and here the separation between the shot-point and geophones was increased so that the reflected longitudinal waves reached the detectors before the slower surface waves. Robin, in Dronning Maud Land, obtained his best records with charges fired at the bottom of boreholes and detected reflections from the bottom of ice up to 2400 metres thick. Single air shots have also been used, the charge being exploded 1 or 2 metres above the surface. Less energy is introduced into the ice than with deep charges but the proportion of

energy travelling as low-velocity, low-frequency, surface waves is reduced. A further method, due originally to Poulter,[1] is to explode simultaneously a pattern of seven or more air charges; the distance between the charges is arranged so that, except in the vertical direction, the waves from the charges interfere with each other. Thus a plane wave is generated at the surface of the firn and less energy is lost in travel through the ice than with a wave spreading from a single point, in which the intensity decreases with the square of the distance from the shot point. In southern Greenland the French obtained reflections at nearly all of their stations, using one of two sets of six-channel seismic apparatus and firing a single charge, usually of about 1 kilogram, near the surface. Robin, in Dronning Maud Land, also using a six-channel apparatus but firing his charges in boreholes up to 7 metres deep, obtained satisfactory reflections at most of his stations.

The seismic work of the British North Greenland Expedition.—During the summer of 1953, G. F. Cadd used the seismic apparatus which Robin had had in the Antarctic, with only minor modifications. Preliminary experiments carried out at "Northice" (78° 04′ N., 38° 29′ W., altitude 2345 metres) showed that much larger charges were required to produce clear records of surface P waves than had been found either by the French or by Robin. Charges varying from 60 grams to 90 kilograms were fired at distances varying from 1·8 metres to 3 kilometres from the nearest geophone. Shots were fired above the surface at heights up to 2½ metres, and below the surface as deep as 4 metres, but in none of the seismograms is any reflected wave discernible. Similar experiments were completed by G. F. Cadd and R. J. M. Bruce at eleven other places between "Northice" and Dronning Louise Land during the summer and autumn of 1953 but at none of them was there any return of energy detected which could be identified with certainty as a reflection. Early in 1954 a twelve-channel portable reflection seismograph was dropped by parachute to the expedition. The sensitivity of this instrument was appreciably greater than that of the other instrument and, in general, the records produced were clearer.

During the early summer of 1954 experiments were made by R. J. M. Bruce at twelve points on a traverse from Dronning Louise Land, via "Northice," to station B 102 (see map, Fig. 2) but at none of these was any reflection distinguishable. Poulter pattern shots were included in the experiments at the seven most westerly of these stations. Using the same pattern of charges (seven air shots, each of about 60 grams, at the corners and centre point of a hexagon of side 11·8 metres, and fired 2 metres above the surface) excellent reflections were obtained at the next station, B 107, although no reflection of energy is detectable at the appropriate part of the records obtained with single air shots. Similarly, reflections were also obtained at twelve other points, as shown in Figure 3, and at some of these readable reflections were also obtained with single air shots. However, no reflections could be detected at stations H, C 3 or C 4. Examples of the seismograms obtained at three stations are given in Figure 4. Thus a line can be drawn so that at stations east of it no reflections have been observed, while west of the line clear reflection records have been obtained at all stations. If energy reflected from the ice-bedrock interface reaches the surface at stations east of the separating line the reflection coefficient is certainly less than 1/100th of that at points west of it.

From the ice thicknesses determined at points west of the line it is possible to draw sub-surface contours in this limited area. These are shown in Figure 3. The greatest thickness of ice, at station G, is 2995 metres (assuming a value for the maximum velocity of 3900 metres/sec.) so that here the bedrock is approximately 200 metres below sea level. In general the bedrock rises to the west, though the result obtained at C 2 may indicate the presence of a trough running approximately parallel to the demarcation line. The distances between the pairs of stations B 102 and B 107, C 2 and C 3, and G and H are about 30 kilometres.

[1] Poulter, T. C., *Trans. Amer. geophys. Un.*, **28** (1947) 162–70 and 367–84.

The nature of the separating line

Geological considerations.—Because the separating line is so well defined it is tempting to seek a geological reason for the difference in character of the interface to east and west of it. For waves normally incident on an interface the reflection coefficient, R, is given by $R=\frac{\rho_1 V_1-\rho_2 V_2}{\rho_1 V_1+\rho_2 V_2}$ where ρ_1, ρ_2 are the densities of the two media and V_1 and V_2 are the corresponding seismic wave velocities. Thus, if the reason for the absence of reflections is that the acoustical impedance, ρV, of the underlying rock is the same as that of the ice, so that $R=0$, then $\rho_1 V_1$ and $\rho_2 V_2$ must be equal. For ice $\rho=0{\cdot}9$ and $V\simeq 4000$ metres/sec. The underlying rock is almost certain to have a density of at least 2·7 gms./cm.^{3}, so that the longitudinal wave velocity is about 1300 metres/sec. Such a value is too low for any rock type, except sands, marls and clays but it could apply to unconsolidated or unfrozen moraines. In southern Greenland the French, using refraction methods, have determined the velocity in the layer immediately below the ice as 4000 to 5000 metres/sec., which corresponds closely with velocities determined in permafrost in Alaska and Russia. The thickness of the layer was 200 to 300 metres. Because the area is remote from any in which the solid geology can be studied, it is difficult to prove any assumption that the separating line is connected with a major geological fault, but even if the surface rock types were appreciably different east and west of the line, because of large vertical movements and subsequent erosion, only small changes would be expected in the reflection coefficient.

Physical considerations: temperatures in the inland ice.—In the area under consideration the altitude of the upper surface of the inland ice varies from 2300 to 2800 metres, while the ice thickness is of the same order. At "Northice" the mean annual temperature of the firn at a depth of 15 metres was found to be −28° C., while the present rate of accumulation is approximately 10 cm./year (water equivalent). The corresponding figures at the French "Station Centrale" (70° 54·8′ N., 40° 38′ W., altitude 2994 metres) are −28° C. and 20 centimetres water equivalent. The geothermal heat flow varies little from place to place in the northern hemisphere and if it is assumed that the value of the heat flow under the Greenland ice sheet is the mean of the values measured elsewhere, namely 38 calories/sq. cm./year, then in the absence of accumulation the temperature gradient set up in ice would be 1° C. per 44 metres. Robin [1] has shown that the effect of accumulation is to reduce the temperature difference between top and bottom surfaces required to conduct away the geothermal heat. Applying his results to Greenland it is found that the temperature difference required in the north is approximately 32° C. and in the south about 22° C. Although other sources of heat have been neglected, for example that produced by the movement of the ice, it is unlikely that the inaccuracies in the assumptions made in obtaining these figures are large. At the French "Station Centrale" the temperature at the bottom of the ice is probably just below the pressure melting point of ice, whereas in northern Greenland, because of the lower accumulation rate, it is almost certainly at the pressure melting point. The part of the geothermal heat which is not conducted away causes a small amount of melting.

Other observations afford some confirmation of this suggestion that there is bottom melting in north Greenland. Nye [2, 3] has considered the equilibrium form of an ice sheet and, assuming only that the ice is a perfectly plastic material in which the yield stress is known and that the ice rests on a bed which is perfectly rough, has shown that a simple relationship exists between the slope of the upper surface at a point and the ice thickness. The thicknesses obtained by the French in southern Greenland show that the value of the shear stress there is about 0·9 bars, a value

[1] Robin, G. de Q., *J. Glaciol.*, **2** (1955).
[2] Nye, J. F., *Proc. Roy. Soc.*, **A 207** (1952) 554–72.
[3] Nye, J. F., *Nature, Lond.* **169** (1952) 529.

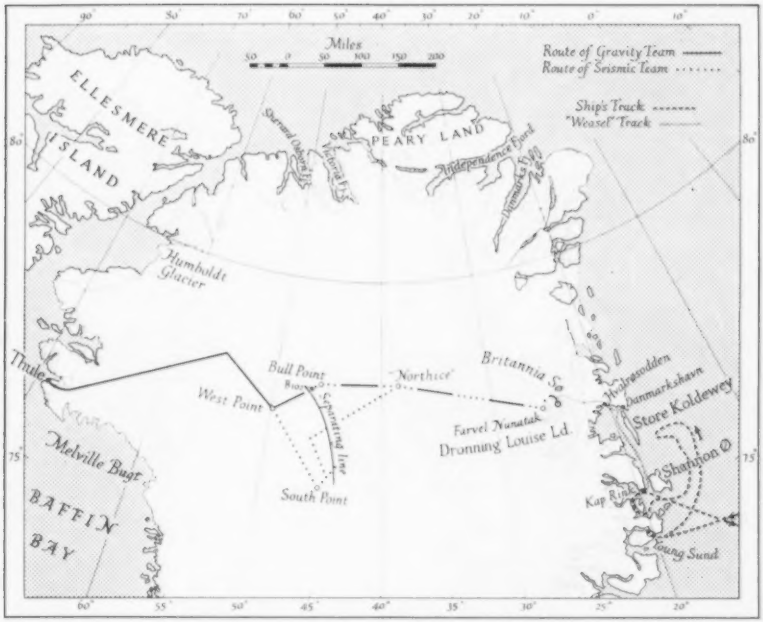


Figure 2

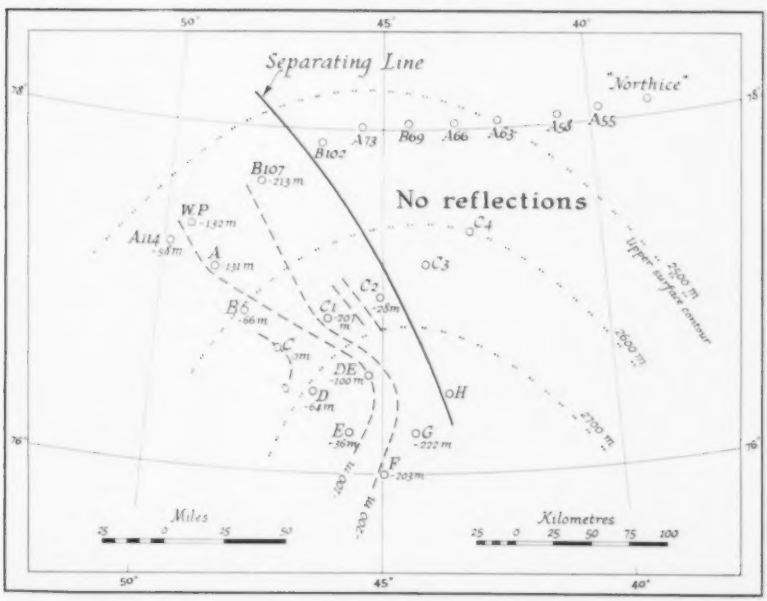


Figure 3

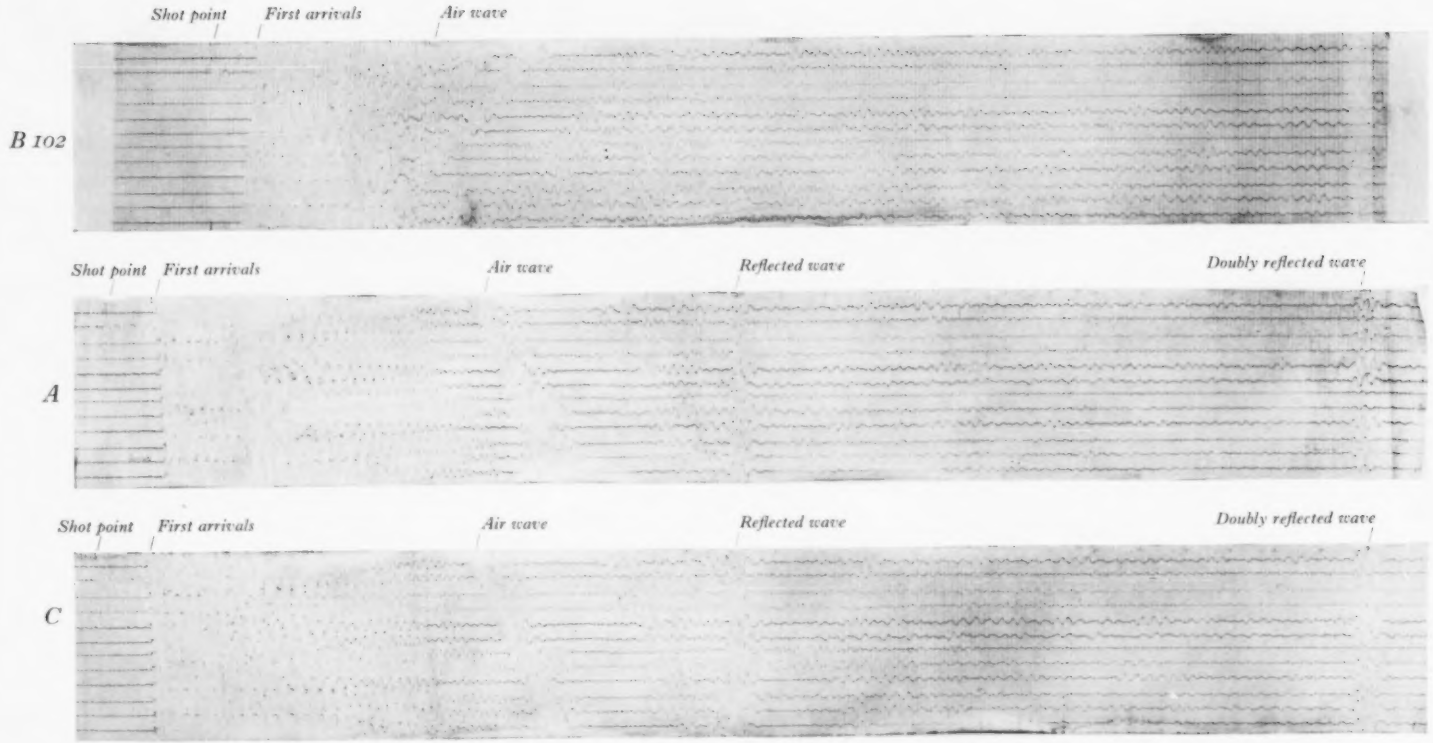


Fig. 4. Seismograms obtained at stations B 102, A and C with Poulter pattern shots

similar to that obtained by Glen [1] in laboratory experiments on the deformation of poly-crystalline ice. Calculating the thickness of ice in northern Greenland from the surface slopes, assuming this value of 0·9 bars for the shear stress, it is found that the bottom of the ice should be more than 1000 metres below sea level in the central area. Such a depression is not found.

Using thicknesses determined directly from the seismic experiments and calculated from measured values of gravity, it is found that the shear stress at the bottom of the ice is about 0·6 bars. Thus it may not be essential for the yield stress to be overcome before the ice moves. If the bottom of the ice is melting, and a "lubricating" layer exists, movement may take place by slip along this, rather than by shearing within the ice. There are other possible reasons for the breakdown of the hypothesis. Nye assumes that the ice is moving laterally at all points, which probably is not justified near the highest parts of the ice sheet under any conditions, and elsewhere only if the rate of accumulation is greater than the bottom melting. This will be so in north Greenland because the rate of melting will not exceed 1 centimetre per year even if the rate of production of heat by shearing within the ice is as great as the geothermal heat flow. Other possible causes for the failure in north Greenland of this hypothesis can probably be dismissed. They include ideas that there are appreciable differences in the structure and the preferred orientation of crystals, or that the stress-strain relationships are different in the two regions. Thus it may be concluded tentatively that the principal difference between conditions in southern and northern Greenland is that under the central part of the northern area the bottom of the ice is melting, while in the south it is not.

Loss of seismic energy by scattering.—Little is known of the seismic reflecting properties of an interface between ice and water or between ice and wet moraine. For an ice-water interface the calculated reflection coefficient is 0·16, while the best results of Robin and Poulter indicate a reflection coefficient of about 0·11. These were obtained on shelf ice, where the interface between water and ice is sharp. However, in northern Greenland it is unlikely that sufficient water is present to form a definite layer between the ice and the underlying material which, if moraine, would be saturated. As with glaciers it is probable that the lowest layers of the ice contain considerable quantities of rock debris. There will be some scattering of seismic energy in this layer but it will not reach serious proportions unless the thickness of the scattering layer is of the order of 1 seismic wavelength, that is about 70 metres. However, it seems probable that the ice will be resting on some thickness of water-logged moraine, the acoustical impedance of which may be approximately the same as that of the ice, as pointed out earlier, so that the energy reflected at the boundary between ice and wet moraine is small. The loss of seismic energy in the wet moraine is great. If, for the purpose of calculation, the mean size of the pores in the moraine is assumed to be the same as that of the grains, and the ratio of the seismic velocities in the solid and the liquid is 3·5 : 1, the amplitude of the seismic wave will be reduced to 1/e of its initial value in traversing approximately 50 metres.[2] The correct values of the porosity and the velocity ratio are not known, but this estimate of 50 metres will not be greatly in error. If, to the east of the separating line, the ice sheet were underlain by 100 metres of moraine, while to the west the thickness were only 50 metres, the amounts of seismic energy reaching the surface after reflection at the moraine-bedrock interface in the east and in the west would be in the ratio of $1 : e^4$.

Although some of the estimates used above have been very approximate it does seem possible that the observed phenomenon (of having distinct areas in which reflections are and are not obtained) can be explained by assuming that the bottom of the ice is melting and that the thickness of ground moraine varies greatly across the demarcation line.

[1] Glen, J. W., *J. Glaciol.*, **2** (1952) 111–14.
[2] Jeffreys, H., 'The Earth,' 3rd ed., Cambridge, 1952.

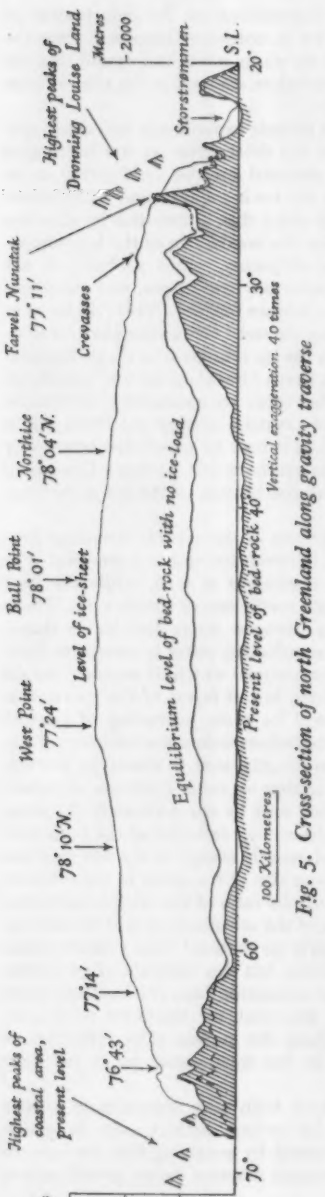


Fig. 5. Cross-section of north Greenland along gravity traverse

Gravity measurements: the formation of the inland ice

It is interesting here to consider briefly some of the results of the gravity measurements made on the inland ice. The gravity traverse follows the seismic route between stations B 102 and B 107, across the demarcation line, but no changes occur in the gravity values which cannot be explained by minor variations in the altitude of the bedrock. Following arguments given by Vening Meinesz [1] it has been possible from the values of gravity along this traverse of the inland ice to calculate the equilibrium altitude of the underlying rock in the absence of the ice sheet. This position is shown in Figure 5. Although simplifying assumptions have been made in obtaining this profile, it is clear that over most of the central part of north Greenland the equilibrium altitude of the bedrock would be about 1000 metres. For comparison, the altitudes of the highest peaks of the eastern and western coasts of north Greenland are also indicated on the diagram. The peaks of the eastern coast, rising to 2800 metres in southern Dronning Louise Land, are much higher than any mountains in north, north-west or north-central Greenland.

One possible method of formation of the ice sheet has been described briefly by Cailleux,[2] and can be extended to apply to north Greenland. With a deterioration of climate, glaciers formed first in the higher coastal regions; those glaciers which flowed to the central, lower parts of Greenland coalesced there, the subsequent growth of the ice sheet being by a process of "altitude autocatalysis." In north Greenland the bulk of the ice must have flowed originally from the east, since no high land of appreciable area exists in the west or north. The winds bearing this snow were probably north-easterlies, but as the total quantity of ice in the north polar region increased, the prevailing winds may have become westerlies, by a "switch" process similar to that suggested by Brooks.[3] If the westerlies were drier (which is probable since they would have to cross the continental mass of North America before reaching

[1] Vening Meinesz, F. A., 'Gravity Expeditions at Sea,' Vol. 4, Delft, 1948.

[2] Cailleux, A., *Rev. Geomorphol. dyn.*, **3** (1952) 1–19.

[3] Brooks, C. E. P., 'Climate through the ages'. London, 1949.

Greenland) and if the change in prevailing wind direction occurred when the ice from the eastern region had advanced only as far as the area of the demarcation line, it would be possible to have conditions in which the ice receded and advanced several times over the central part of northern Greenland, during which large quantities of moraine were deposited. If, subsequently, the western part of north Greenland were covered by a rapid advance of the ice, or by the formation of a thin ice sheet by accumulation in that area rather than by ice flowing from the east, the ground moraine there would be appreciably thinner than in the east.

Conclusion

Although the hypothesis given above is tentative in the extreme, it can be used to explain the lack of seismic reflections in the central part of north Greenland and the sharpness of the line separating reflecting and non-reflecting areas. However, in the eastern part of the non-reflecting area the ice is thin enough for the underlying moraine to be frozen, and here an alternative explanation for the lack of reflections must be sought. Unfortunately there was not time at the end of the expedition to try Poulter pattern seismic shooting near the eastern margin of the inland ice, and it is by no means certain that such experiments would not have produced definite reflections. Had this been the case the eastern limit of the non-reflecting area probably would have been ill-defined, and would have marked the eastern limit of water-logged moraine. Nor was there an opportunity to make seismic stations, closely spaced, between the pairs of seismic stations which at present define the position of the separating line. However it is hoped that this work will be undertaken by the forthcoming International Glaciological Expedition to Greenland, and that from their results additional information will be obtained about the different conditions on the two sides of the demarcation line.

V. DETERMINATION OF THE ALTITUDES OF POINTS ON THE GREENLAND ICE SHEET BY MEASUREMENT OF ATMOSPHERIC PRESSURE

R. A. HAMILTON

This note describes the method of determining the altitude of points on the inland ice at which a geophysical party of the British North Greenland Expedition carried out experiments to determine the thickness of the ice sheet, and at which measurements of atmospheric pressure were made.

In order to determine the altitude of a point by the measurement of the atmospheric pressure, it is necessary also to determine the pressure at a second point on a standard level of known altitude vertically above or below the first point, and the mean temperature of the column of air between the two points. The fundamental equation is

$$H_1 - H_2 = \frac{R}{g}\int_1^2 T\,\frac{dp}{p} \qquad \ldots\ldots\ldots \quad (1)$$

where H_1, H_2 are the altitudes of the point and of the standard level, T is the temperature of the air at a level where the pressure is p, R is the universal gas constant, g the acceleration due to gravity: the integration is carried out from the point to the standard level. We define a temperature $\overline{T}$ by the equation

$$\int_1^2 T\,\frac{dp}{p} = \overline{T}\int_1^2 \frac{dp}{p} = \overline{T}\,(ln\,p_2 - ln\,p_1)$$

and over the short vertical distances under consideration in this note, we can take T as

the mean temperature of the air between levels 1 and 2. The fundamental equation now becomes

$$H_2 - H_1 = 67{\cdot}4\ \overline{T}\ (\log p_1 - \log p_2) \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

where H_1, H_2 are measured in metres, $\overline{T}$ in degrees absolute.

The altitude measurements made on the earlier crossings of Greenland were computed from (2), the standard level chosen being mean sea level. This involves not only the assumption of a mean temperature of a non-existent air column but also the assumption of a hypothetical pressure at mean sea level vertically below the point on the inland ice.

The 700 mb. level was used as standard by Bedel[1] in determining altitudes from pressure measurements made by Expéditions Polaires Françaises (E.P.F.), and this procedure has been followed here for computing the altitudes from the B.N.G.E. pressure measurements. Bedel did not discuss the accuracy of the determinations, but estimated the accuracy as ±40 metres. In the case of the B.N.G.E. determinations the standard error is certainly less than this, as the party moved more slowly than E.P.F. and took more pressure readings with better instruments at each point.

Meteorologists are now able to draw 700 mb. charts twice daily for most of the civilized parts of the globe. On the chart is plotted the altitude above m.s.l. at which the atmospheric pressure is 700 mb. and the meteorologist draws contour lines (in this case at 200 feet = 60 metre intervals) of the 700 mb. surface. The altitudes which are plotted are determined by radio-sondes which are sent up from stations at 0300 and 1500 G.M.T. From these charts, therefore, the 700 mb. altitude can be estimated for any geographical position, the accuracy of this estimate depending on the accuracy of the radio-sonde measurements, the closeness of the stations, and the complexity of the contour pattern. It is equivalent to reading the altitude of a point on undulating land from a map with 200-foot contours.

In Greenland there are radio-sonde stations distributed round the coast, but none in the interior. During the summer of 1954 pressure and temperature measurements were made by three parties in the northern part of the inland ice. These are designated as follows:

N. A fixed station "Northice" (78° 04′ N., 38° 29′ W.), the altitude of which was measured by theodolite methods. Pressure was measured by two mercury barometers and temperature by thermometers in a Stevenson screen.

G. The party which carried a gravity survey from near "Northice" to Thule in north-west Greenland. The gravity stations were about 5 kilometres apart: at each station two pressure readings were made on an aneroid, and two temperature measurements by a whirling psychrometer. The altitude of each station was determined by theodolite methods.

S. The party which measured the thickness of the ice sheet by seismic methods. This party travelled quickly from one station to the next, but took several pressure readings on three aneroids at three-hourly intervals around 1500 G.M.T., together with air-temperature readings by whirling psychrometer, at each station.

It is the altitude of S that we wish to determine. Thus by writing $p_2 = 700$ in (2) we can evaluate H_7, the 700 mb. altitude for N and G, from the equation

$$H_7 - H = 67{\cdot}4\ \overline{T}\ (\log p - \log 700) \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

and thus we obtain two more values to plot on the 700 mb. chart: this enables the contour lines to be drawn with greater accuracy and detail as to shape in the neighbourhood. Finally, then, H is estimated for the position of S from the completed chart, and H is deduced from (3) using the appropriate values of $\overline{T}$ and p for S.

Measurement of pressure, p.—The aneroids, which were compensated for temperature changes, were compared with the mercury barometers at N in approximately

[1] *Ann. Géophys.* **10**, 2 (1955).

the same range of pressures as those experienced in the field, and at approximately the same temperatures as those inside the caravan in which they travelled. The root mean square difference between the pressures determined by aneroids and by mercury barometer was 0·2 mb.

Measurement of mean temperatures, $\bar{T}$.—A study has been made of the vertical distribution of temperature at 1500 G.M.T. during the months of June and July 1951 at "Station Centrale," the station on the inland ice (71° N., 41° W., 2993 metres) established by E.P.F. The normal pattern was a gradual decrease of temperature of 4° C. in the lowest 500 metres above screen level. Exceptions to this pattern were rare and the root mean square of the difference between the observed temperature at 500 metres above the surface and the temperature derived by subtracting 4° C. from the screen temperature was only 1·3° C. To determine the 700 mb. temperature at the positions N, G and S we have subtracted from the observed 1500 G.M.T. temperatures 1° C. for each 12 mb. the measured pressure exceeds 700 mb. The 700 mb. temperature estimated in this way varies little from day to day, except when there is a change of air mass after passage of a front, and we can assume that all diurnal temperature change takes place in levels below this. If, therefore, we compute the 700 mb. level temperature from the 1500 G.M.T. station level temperature and take $\bar{T}$ as the mean of this and the observed station level temperature, the standard error in estimating $\bar{T}$ is likely to be around 1° C.

Estimate of 700 mb. altitude, H_7.—In the case of N the 1500 G.M.T. values for p and $\bar{T}$ are substituted in (3). A slight difficulty arises with G, for readings were not always taken at 1500 G.M.T. and the best use must be made of those taken at other times (usually between 1400 and 2359 G.M.T.). Moreover G was moving, though so slowly that a day's travel is scarcely appreciable on the scale of the 700 mb. chart, but changes of altitude from station to station must be taken into consideration. Accordingly for each station, from the appropriate value of p, $\bar{T}$ and H, a value of H_7 is computed, and the values for H_7 are plotted on a time chart. A mean curve drawn through these points shows the change of H_7 during the period of working on that day, and this, when due consideration has been given to the meteorological situation, should be similar to the change of H_7 at N, where the barograph trace gives a continuous trace of change of pressure, and thus, very nearly, of H_7. The mean curve for G helps to smooth out the irregularities due to the pressure having been read only to the nearest millibar, and makes some use of the readings made later in the day. Where the mean curve cuts the 1500 G.M.T. line, extrapolated slightly sometimes, there is read the value for H_7 for the 1500 G.M.T. position for G.

Determination of altitude, H. of S.—In order to make some use of readings taken by S at times other than 1500 G.M.T., procedure similar to that used for G is adopted. At any one station a value of H_7-H is deduced for each time of measurement of p and $\bar{T}$, a time curve for H_7-H is drawn. This will be generally similar to the curves for G and N, and the appropriate value of H_7-H for 1500 G.M.T. is read off. H_7 is estimated from the 700 mb. chart, and thus H is determined.

Discussion of errors

(*a*) *Temperature.*—The thermometer at N had been calibrated by the N.P.L. and the thermometers carried by S and G were compared with it, and found to agree to within about 0·2° C. The error in actual measurement of the air temperature is thus small, and does not influence the previous estimate of the standard error in $\bar{T}$ as about 1° C., equivalent to an altitude error of 1 metre for each 250 metres height difference between the Inland ice surface and the 700 mb. level. In the cases of N and S this amounts to about 2 metres. In the case of G the variation is greater, but 3 metres may be taken as an outside figure.

(*b*) *Pressure.*—The standard error in measurement of pressure at N is estimated to be 0·2 mb., *i.e.* 2 metres, and at S of 0·3 mb. *i.e.* 3 metres. In the case of G the error is larger, and will be discussed later.

(*c*) *Error of altitudes plotted on the 700 mb. chart.*—The standard error in the determination of a 700 mb. altitude by radio-sonde is around 5 metres.

Assuming for the moment that the altitudes of N and G are correct, the error of the plotted 700 mb. altitude at N is due to an error of 2 metres on account of temperature and 2 metres on account of pressure, *i.e.* a standard error of 3 metres.

In the case of G, pressures were read on only one aneroid. Two readings were made at each station and about five readings in a day, but each reading was made only to the nearest millibar. The discontinuities due to this are somewhat smoothed out by the plotting, and the standard error due to pressure in estimating the 1500 G.M.T. value of the 700 mb. altitude is estimated at 6 metres. The contribution due to temperature is 3 metres giving a standard error of 7 metres.

The error on the chart of the 700 mb. altitude at S is influenced mostly by the value of the plotted 700 mb. altitudes at N and G (when in the vicinity), less so by the more remote radio-sonde stations. It is difficult to estimate this error for S which varied in position between about midway between N and G and a point that makes an equilateral triangle with them. The standard errors for G and N being 7 metres and 3 metres respectively, we estimate that the standard error at S is 6 metres. The standard error in H_7 (at S), therefore, amounts to 6 metres when G is in the vicinity, and to 3 metres when it is too far away, and too low, to be of use.

(*d*) *Error in drawing the 700 mb. chart and reading the value of an altitude from it.*—This error arises when drawing the chart from the uncertainty of the exact shape of the contours—the sharpness of a ridge or the flatness of a col. The actual error will differ from day to day according to the complexity of the chart. The contour lines of the 700 mb. surface are drawn at intervals of 200 feet (60 metres) and it is estimated that the standard error in determining a value of H at a point on the chart amounts to about 30 feet (9 metres) when the gravity party is in the vicinity and 40 feet (12 metres) when it is distant.

(*e*) *Error in determining* H_7-H.—This arises from an error of 3 metres due to pressure and 2 metres due to temperature, a standard error of about 4 metres.

Thus it will be seen that the standard error in determining H from the observations made on a single day and referred to a single 700 mb. chart amounts to

(i) $(6^2+9^2+4^2)^{1/2}=11$ metres when G is in the vicinity; and
(ii) $(3^2+12^2+4^2)^{1/2}=13$ metres when G is distant.

It appears as if the presence of *G* in the vicinity does not add greatly to the accuracy of the determinations. This is not quite true, however, for from the charts on which N, S and G were all grouped conveniently around the north–south ridge of the inland ice experience was gained in drawing the details of the contours there, experience which was used later when G was not available.

Considering all the observations together, the estimated standard error E is taken as 12 metres. Let us now see how it agrees with the value derived from the computed altitudes themselves. From the eleven cases in which the altitudes were computed from observations on two different days, the root mean square deviation of the individual values from their mean is 5·5 metres. This should be equal to $\sqrt{\frac{n-1}{n}}\,E$ where $n=2$, giving $E=8$ metres, compared with our estimate of 12 metres. Thus if we take the mean of these two determinations we obtain 10 metres.

Now on almost all occasions two determinations were made of each altitude. If there were no correlation between the charts on the two days the standard error of the mean would be $10/\sqrt{2}$, *i.e.* 7 metres. The charts, however, are not quite independent of one another in that when drawing the one chart the meteorologist is influenced to some extent by the previous chart drawn twelve hours earlier. The correlation after twenty-four hours is small and we might, therefore, estimate the standard error for the mean of a pair of altitude determinations to be 8·5 metres.

These errors have referred to the altitudes relative to N. The standard error of the determination of the altitudes of N and G by theodolite methods is 10 metres. Thus the estimated standard error in the determination of the altitudes of S is 13 metres.

On four occasions altitudes were determined by this method at gravity stations whose altitudes were also determined by geodetic methods. The errors in these cases were −6 metres, nil, −14 metres, −15 metres. In the third case the meteorological situation was one of unusual complexity with a front and small depression causing an indentation of about 10 metres in the 700 mb. surface in the neighbourhood of N. In the fourth case the altitude was determined from one observation only of p and T. In all the cases when altitudes of S have been determined by this method, at least three observations were made, spread over two or more days, except in one case when three observations were made on one day only. It will be noted that the three of the four values of error are negative, the fourth being zero. This has been carefully investigated and the conclusion has been reached that it is not significant (there is a 1 in 4 chance that all three will be of one sign), and that the method does not lead to low values of altitude. In computing the means of the altitudes determined for different days each value has been weighted according to the number of observations on that day. The maximum difference between this and the arithmetic mean is only 5 metres.

Acknowledgements

I wish to express my thanks to many who have helped me with advice and by taking observations, and to the Director of the Meteorological Office for permission to publish this note.

APPENDIX

Altitudes of Seismic Stations on Inland Ice

Date	*Lat. N.*		*Long. W.*		*Station*	*Times of observation G.M.T.*	*Computed altitude metres*	*Altitude metres (weighted mean)*
June	°	′	°	′				
12	77	10	48	51	A.20	18	2537	
13	77	10	48	51	A.20	12, 15	2553	
								2547
14	76	56	48	05	B.40	12, 15, 18	2603	
								2603
15	76	43	47	20	C.60	18	2667	
16	76	43	47	20	C.60	12, 15, 18	2672	
	76	43	47	20	C.60			2671
17	76	27	46	31	D.80	18	2690	
18	76	27	46	31	D.80	12, 15	2688	
	76	27	46	31	D.80			2689
19	76	12	45	46	E.100	18, 21	2737	
20	76	12	45	46	E.100	12, 15, 18	2746	
	76	12	45	46	E.100			2742
22	75	59	45	00	F.120	12, 15, 18	2777	
23	75	59	45	00	F.120	12	2767	
	75	59	45	00	F.120			2774
24	76	13	44	22	G.140	12, 15, 18	2774	
27	76	13	44	22	G.140	15	2789	
								2778
25	76	26	43	36	H.160	18, 21	2771	
26	76	26	43	36	H.160	12, 15	2771	
								2771

Altitudes of Seismic Stations on Inland Ice—continued

Date	*Lat. N.*		*Long. W.*		*Station*	*Times of observation G.M.T.*	*Computed altitude metres*	*Altitude metres (weighted mean)*
June	°	′	°	′				
27	76	33	45	19	DE.20E	21	2740	
28	76	33	45	19	DE.20E	12, 15, 18	2732	
29	76	33	45	19	DE.20E	12	2730	
								2733
29	76	53	46	12	C1.20E	21	2679	
30	76	53	46	12	C1.20E	12, 15, 18	2700	
								2695
July								
1	77	02	45	08	C2.40E	18	2655	
2	77	02	45	08	C2.40E	12, 15, 18	2667	
	77	02	45	08	C2.40E			2664
3	77	12	44	02	C3.60E	18	2649	
4	77	12	44	02	C3.60E	12, 15, 18	2653	
								2652
5	77	23	43	01	C4.80E	18	2624	
6	77	23	43	01	C4.80E	12, 15	2612	
								2616

Altitudes of Gravity Stations

Date	*Lat. N.*		*Long. W.*		*Station*	*Times of observation (G.M.T.)*	*Computed altitude metres*	*Altitude metres (weighted mean)*	*Geodetic altitude metres*
May	°	′	°	′					
30	78	03	44	24	B.69	15, 18	2525	2525	2531
June									
1	77	56	46	27	B.102	12, 15, 18	2521		
2	77	56	46	27	B.102	12, 15	2508		
								2516	2516
5	77	40	47	56	B.107	15, 18	2510		
6	77	40	47	56	B.107	18	2516		
								2512	2526
11	77	24	49	26	B.112	12	2515	2515	2530

VI. GLACIER REGIME IN NORTH-EAST GREENLAND

H. LISTER

From analysis of meteorological records [1] and [2] from Ahlmann's classic work on glacier recession [3] it is now well established that the climate over the North Atlantic has been warming up, perhaps increasingly so, during the last quarter

[1] Manley, G., 1946, "Temperature trend in Lancashire 1753–1945," *Quart. J. R. met. Soc.*, **72**, 311, p. 25 (pp. 1–31).

[2] Eythorsson, J., 1949, "Temperature variations in Iceland," *Geogr. Ann. Stockh.*, 1–2, p. 51 (pp. 36–55).

[3] Ahlmann, H. W., 1949, "Glaciological research on the North Atlantic coasts" R.G.S. Research Series 1, p. 67 (pp. 1–80).

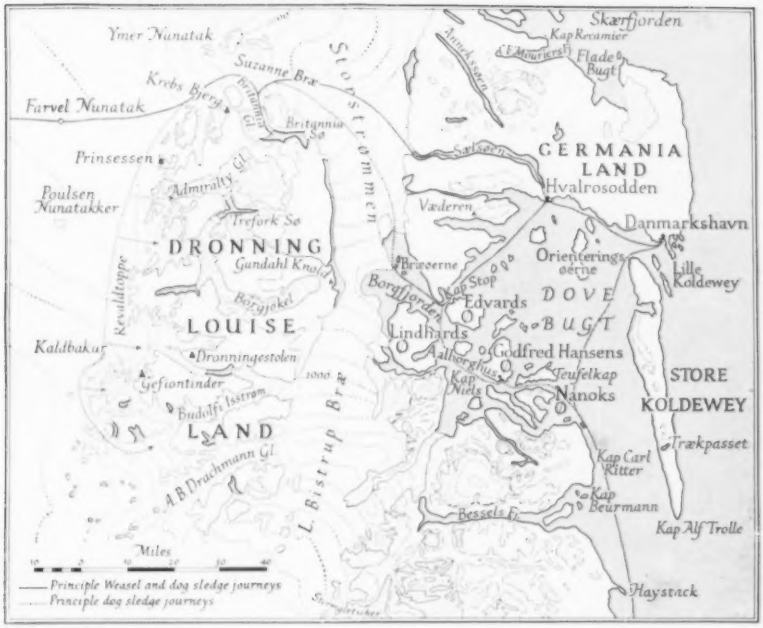


Figure 1

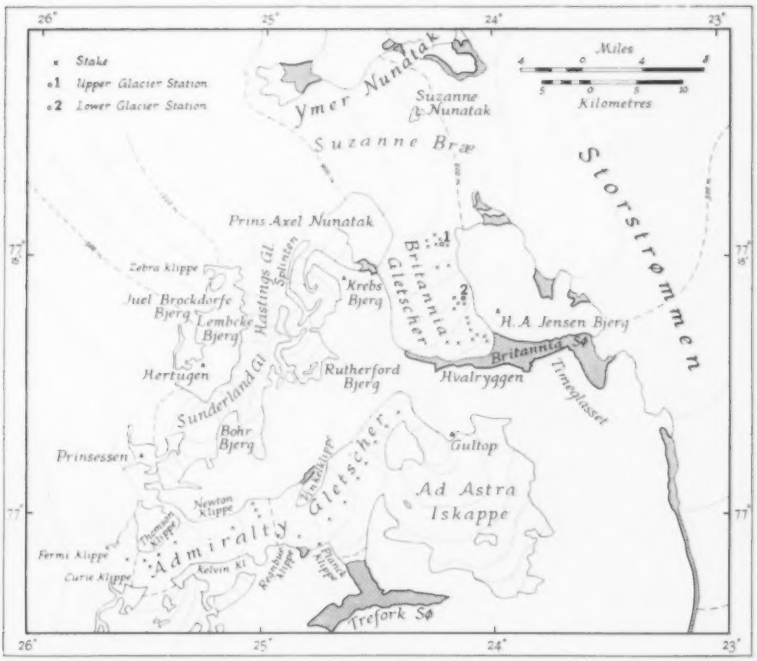


Figure 2

1. The undulating surface of Britannia Gletscher

2. Weighing snow blocks

century. In Greenland the glaciers have been receding up the fjords but, until the investigations outlined here were made, no research had been carried out on the regime of glaciers from the inland ice.

Dronning Louise Land, the base of the British North Greenland Expedition, approximately lat. 77° N., long. 23° W., is surrounded by ice and ribboned by glaciers (Fig. 1). This composite nunatak, about 120 kilometres north to south and about 60 kilometres west to east, is within 30 kilometres of Dove Bugt at its nearest point, but the average distance from the coast is nearly 80 kilometres. This so reduces the maritime effect that the glaciers of Dronning Louise Land are primarily in a continental influence and thus we might expect their regime to be somewhat different from that of most glaciers studied round the North Atlantic coasts.

Two glaciers representative of Dronning Louise Land were observed: Admiralty Gletscher, 30 kilometres long by 5 kilometres wide and Britannia Gletscher, 14 kilometres long by 8 kilometres wide (Fig. 2). Three main characteristics of altitude, gradient and surface roughness obviously affected the amount of change of the surface level. The glaciers were divided into areas of approximately common gradient and degree of surface undulation (Table 1).

Table 1.—*Three morphological zones of Britannia Gletscher*

	Lower glacier	*Middle glacier*	*Upper glacier*
Height interval (metres)	223 to 430	430 to 555	555 to 675
Total area (square kilometres)	36	37	39
Ice surface	Steep with big hummocks.	Gentle slope below moderately steep ramp. Medium ice hummocks and ridges.	Gentle slope from Suzanne Brae. Small hummocks over undulating surface.
Drainage	Deep gorges	Gorges with dendritic tributary pattern.	Wide gorges, small lakes, moulins. Little marginal drainage.

The depth of snow was measured at bamboo rods drilled into the glacier.[1] Measurements were made at a number of places in each locality as the depth varied very greatly; the steep ice hummocks were bare of snow for most of the winter (Plate 1) while stream channels contained deep drifts of snow. With the mean of the snow depths recorded for each area of the glacier, an estimate was made of the area of glacier covered by snow. Not only did the uneven surface make it difficult to measure a mean snow depth, but the depth could change rapidly; near the head of the glaciers snow lying in one area may be completely removed by the wind a few days later.

The density of the snow was determined by weighing cylinders, or cut blocks (the latter in Plate 2). The cylinders, of known value, were filled with snow, trimmed and weighed. The blocks of snow were cut to shape, measured with calipers and weighed. This method was usually checked by displacement of paraffin oil. Drifting snow frequently interfered with these measurements, and the weighing usually had to be carried out in a tent. The total accumulation on the glaciers was found by adding the product of the mean depths of snow, the percentage area cover and the density of the snow over each glacier zone. Ablation was similarly measured at stakes frozen into the glacier ice. Figure 3 shows diagrammatically the observations on the

[1] Swithinbank, C. W. M., "The use of stakes in measuring the accumulation of snow on glaciers." Union Géodésique et Géophysique Internationale, Assemblée Générale de Rome 1954, Publication no. 39 de l'Association Internationale d'Hydrologie. Vol. 4, pp. 128–31.

Britannia Gletscher. The blocks above and below the datum line represent the accumulation and ablation respectively since the previous observation shown. The height of the block above the line represents the depth of snow accumulated, and the depth of the block below the depth of snow or ice ablated. The length of the block is proportional to the percentage area of the glacier zone covered by snow, or affected by ablation. The short line at each date represents the total glacier surface and the blocks on this line show the mean change to the whole glacier since September; *i.e.* the blocks on the short datum line give a cumulative summary in water equivalent

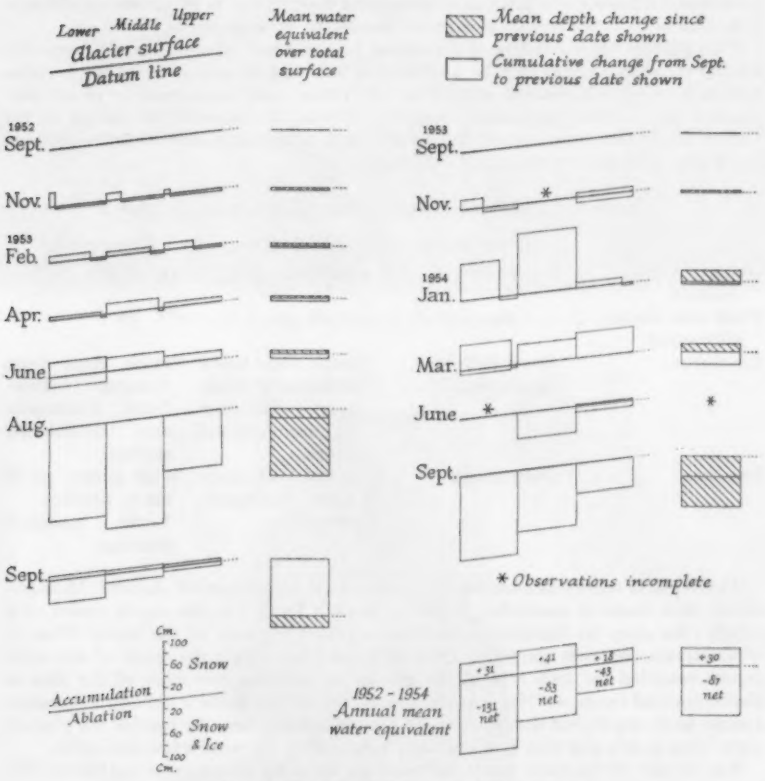


Fig. 3. Regime of Britannia Gletscher

of the changes shown for each of the three zones of the glacier. The shaded blocks represent the mean change, in water equivalent, of the sum of the three areas shown immediately on the left. The mean changes to the glacier surface in two years are shown in depth of water equivalent, and the net ablation is the amount of ablation not compensated by accumulation. The diagram shows the dominance of ablation over all areas of the glacier, the very small amount of snow accumulation providing little to compensate the summer melting.

The wastage of ice from the bare surfaces by sublimation, even with very negative temperatures in winter, meant that ablation occurred during most of the year. Tem-

peratures of the uppermost 6-metre layer of ice were recorded seasonally and indicate that sublimation would be encouraged by the loss from the ice of heat gained during the summer.

A more abundant source of heat existed in the water of Britannia Sø (Plate 3); in this case there was always, except in late spring, a negative temperature gradient through the ice cover. A practical illustration of this winter ablation was provided when a fish, originally frozen into the lake ice, was found with its head protruding owing to the removal of the upper few centimetres of lake ice, by sublimation during winter, with temperatures below freezing point. The fish, illustrated in plate 6, was a Britannia Lake char, a new sub-species of *Salvelinus alpinus* (L).[1] The temperature gradient in the lake ice (Fig. 4) and the wastage of ice from the surface were measured from time to time. A small amount of heat was used to sublime the hoar frost deposited, but hoar frost amounted to less than 0·5 centimetre depth of water equivalent. An approximate rate of sublimation was calculated and found to be nearly four times the observed rate of sublimation, since much of the heat conducted through the lake ice is not used in sublimation but escapes to the air. The hummocky glacier ice, which has much less heat available, due to a less steep temperature gradient, loses three times more ice than would seem possible by sublimation alone. Though the wind turbulence over the rough glacier surface must assist the vaporization, it seems possible that abrasion of the ice surface by wind-blown ice particles accounts for approximately 60 per cent. of the ice removed during the winter. Table 2 summarizes the regime of each of the two glaciers and includes from periodic inspection of the glacier margins, an estimate of the wastage of ice by calving, the total volume so lost being divided by the glacier area to give an equivalent depth of ice as removed from the glacier surface.

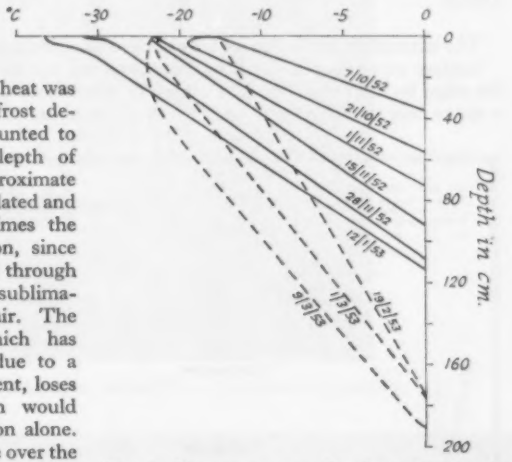


Fig. 4. Temperature profiles in Britannia Sø ice

Table 2.—*Supply and wastage of glacier ice in g./cm²*

Britannia Gletscher 1952–54

Supply			*Wastage*		
Accumulation	1952–3 20·3		Ablation	1952–3 140·5	
(Snow cover)	1953–4 40·1		(Melting and		
mean		30·2	evaporation)	1953–4 94·1	
Hoar frost deposit		0·3	mean		117·3
			Sublimation		2·4
			Calving		1·7
		30·5			121·4
Deficit		90·9			

[1] Private commmnication from G. F. Friend, Department of Zoology, Edinburgh.

Table 2.—*Supply and wastage of glacier ice in g./cm²*—continued

Admiralty Gletscher 1952–3

Supply		*Wastage*	
Accumulation 1952–3 (Snow cover)	14·8	Ablation 1952–3 (Melting and evaporation)	103·8
Hoar frost deposit	0·3	Sublimation	2·3
		Calving	0·5
	15·1		106·6
Deficit	91·5		

The agreement in the figures for the net loss of ice is remarkable.

Surface movement of the Britannia Gletscher was measured at four beacons from the edge to the centre by K. C. Arnold. Movement during one year ranged from 1 metre near the ice edge to 150 metres at the centre (Fig. 5a). From these observed

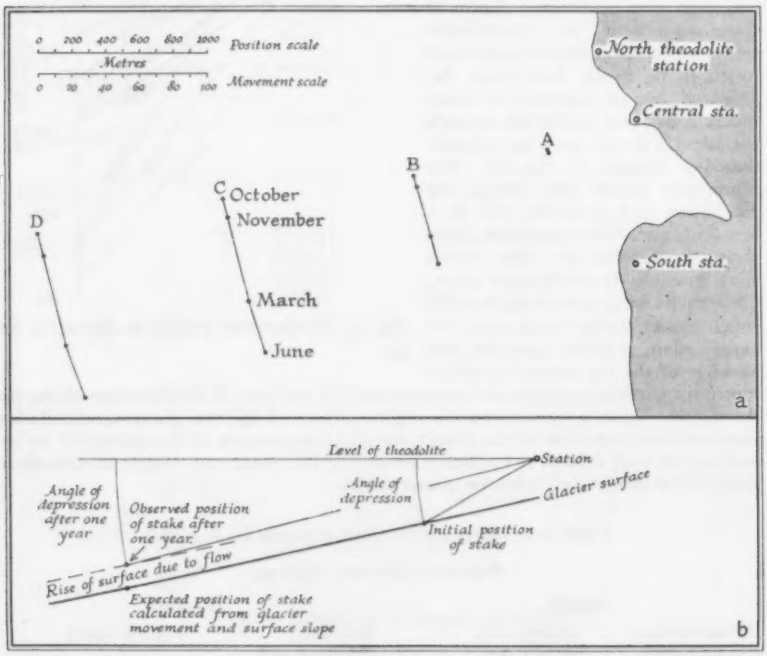


Fig. 5(a). Surface movement of Britannia Gletscher; (b) Increase of glacier thickness, due to forward movement, 1953–4

figures of forward movement and measurement of the surface slope, which gave a gradient of 1 in 48, the expected vertical movement was calculated for each beacon (Fig. 5b). In each case this was less than the observed vertical movement; that is, there was a build-up of the ice averaging nearly 50 centimetres. The mean observed net ablation at this altitude on the glacier was 47 centimetres. Thus on the upper

3. Ice on Britannia Sø buckled by advancing glacier

4. Dating of seasonal snow stratification by strings

5. Pits dug to reveal vertical snow profiles

6. Arctic Char frozen into lake ice and exposed through sublimation

Britannia Gletscher there would seem to be a balance between ablation of ice and compensation by flow from the inland ice.

For a longer term view of the glacier regime, the rocky margin of the ice was searched for any of the hardy arctic plants. Some of these were seen within 3 metres of the ice edge. Only at the western glacier snout was there any newly exposed ground with boulders thinly veneered by fresh glacial clay. Forward movement of Britannia Gletscher was 20 metres in 1952–3 and buckled the 2-metres thick lake ice in front of the advancing glacier (Plate 3). Calving and melting more than compensated for this advance and caused approximately 20 metres recession. Forward movement of Admiralty Gletscher was only measured at the snout and equalled 9 metres in eight months. Ablation and calving almost compensated for this and left the glacier in apparent stalemate save in places along the glacier front where the ice rode high over some terminal moraine, bulldozing some of the coarse debris until, in places, it was a little higher than the ice. The expedition assistant geologist, P. Wyllie, reported a small nunatak at the eastern end of the group comprising Ymer Nunatak. This new nunatak does not appear in the description of the locality, made by Koch and Wegener [1] in 1911.

We may conclude that the glaciers of Dronning Louise Land are almost entirely below the firn line, which is at 1000 metres altitude. The glaciers have a net loss of slightly less than 1 metre depth of water equivalent, but more than half of this is compensated by flow from the inland ice, so that glacier recession is small and is manifest principally in the thinning of the lower ice tongues.

At two stations on Britannia Gletscher, a study was made of the heat balance at the glacier surface. Meteorological observations in the 4-metre layer of air above the glacier surface showed that of the total amount of heat which entered the glacier surface from above the contributions due to radiation, condensation and eddy convection were 69 per cent., 2 per cent. and 29 per cent. respectively. The proportion of this total heat used in melting, evaporation and conduction into the ice were respectively 54 per cent., 34 per cent. and 12 per cent. Research was also carried out on the inland ice and detailed studies made at "Northice," lat. 78° 04′ N. long. 38° 29′ W., altitude 2345 metres; accumulation was measured by erecting stakes, by sounding, and by excavating pits. Seasonal stratification was verified by laying successive strings (Plate 4) or dye on the snow surface, and digging pits to reveal the vertical snow profile (Plate 5). The strings were long and were pegged to the surface to keep a more accurate datum and avoid vibration in the wind. Dye was preferable, but could not be used in the summer because of radiation absorption. After a year during which several strings had been laid, pits were dug on each side of the strings. The sides of the pits revealed the vertical profile of the snow with the strings making horizontal date marks. The sizes of snow crystals taken from the side of the pit were measured by a microscope (Plate 5). Densities of the snow from the side of the pit at different depths were measured by the cylinder (of 40 or 500 cubic centimetres capacity) method. The year's accumulation was weighed directly by cutting vertical columns between two strings which had been set out at a year's interval.

Strings laid down during summer months had between them snow that was fairly open in texture; it was coarse and frequently almost hanging vertically as though the grains were strung together. The winter strings marked very fine-grained, well compacted snow of tiny needle-like crystals. Within these layers could be differentiated thin hard bands of shattered crystals, very tightly packed. These crusts were formed in periods of high wind and were sometimes at such an angle that it was possible to denote a fossil *sastrugi* form from which the wind direction could be estimated. Within a number of the summer layers were thin bands or lenses of

[1] Koch, J. P., and A. Wegener, 1912, "Die Glaciologischen Beobachtungen der Dänmark-Expedition" *Medd. Grønland*, **46**, p. 32 (pp. 1–77).

cemented crystals and some pure ice, all indicative of melting and hence of a comparatively hot summer. When the characteristics of the seasonal layers had been learned, a deep pit was excavated and density, crystal size and thickness of the layers was measured. It was found possible to count, back from the surface, the annual layers—similar to counting the annual rings of a tree. The annual accumulation has been plotted (Fig. 6) and five-year running means added. The results have also been plotted of Sorge [1] who, in 1930 under much more severe conditions, made a similar investigation at Eismitte, lat. 70° 55′ N., long. 40° 38′ W., near the centre of the Greenland ice sheet.

From Figure 6 it will be seen how the average annual accumulation in the 1870's was 14 centimetres of water equivalent, but there was a decrease at the turn of the century and a marked decrease to a little more than 5 centimetres in 1940. There has been a general increase since then, quite marked in 1953–54, with 12 centimetres of water equivalent. There was no great variation from this figure at places on a line

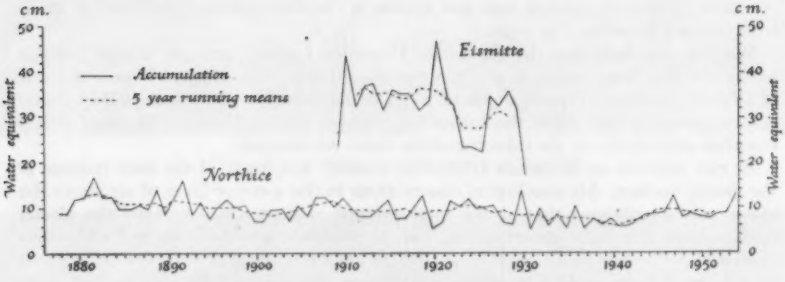


Fig. 6. Net accumulation on inland ice

running 300 kilometres east from "Northice," but very near to the mountains of Dronning Louise Land, there was a sharp decrease in the annual accumulation: Bull found very low values of snow accumulation at Farvel Nunatak. West of "Northice," however, the mean accumulation was generally greater than 12 centimetres. A greater snow accumulation in the west, and a reduced but fairly constant thickness of the annual layer in the east, were also found by Koch and Wegener [2] when they crossed Greenland in 1913, passing 200 kilometres south of "Northice." They found a mean depth of accumulation of approximately 20 centimetres over the eastern half of the inland ice.

It appears that the snow accumulation in north-east Greenland decreased during the last half-century but has increased again during the last ten years. The supply of ice to the glaciers that flow across and round Dronning Louise Land would seem to be assured for the present and only where maritime influence has accelerated the very slow recession, or where high cols have accentuated the reduced flow of transection glaciers, has glacier recession been most marked.

Acknowledgements

I am very much indebted to P. F. Taylor who was assistant glaciologist to the expedition, to R. A. Hamilton, senior scientist, and to Colin Bull, geophysicist.

[1] Sorge, E., 1935, 'Deutsche Grønland—Expedition 1929 and 1930–1,' Part III "Glaziologie," p. 116 (62–270). F. A. Brockhaus, Leipzig.

[2] Koch, J. P., and A. Wegener, 1930, "Wissenschaftliche Ergebnisse der Dänischen Expedition nach Dronning Louises Land und quer über das Inlandeis von Nord-Grönland 1912–13," *Medd. Grønland*, **75**, p. 377 (pp. 1–404).

Many expedition members assisted with the field work and W. V. Lewis and J. E. Jackson of the Geography Department, Cambridge, were ever helpful in discussion. Plate 4 is by P. F. Taylor and Plate 6 by H. E. Lewis. To all I am very grateful.

Britannia Sø basin from the north-west

DISCUSSION

Afternoon Meeting, 14 November 1955

Before the papers were read the CHAIRMAN (Dr. EDWARD HINDLE) said: Probably most of those present had the pleasure last year of hearing the general description given by Commander Simpson of the work of the British North Greenland Expedition which worked in Dronning Louise Land, and on the northern part of the Greenland ice sheet, from 1952 to 1954. The expedition was led by Commander C. J. W. Simpson, a Gold Medallist of this Society and now a member of our Council. He had as second-in-command R. A. Hamilton, who was chief scientist. Mr. Hamilton, who is at present at the Meteorological Office at Prestwick Airport, will open the meeting with a synopsis of papers on the expedition's survey work. When Mr. Hamilton has completed his synopsis, Mr. Lister, senior glaciologist for the whole period of the expedition, will speak, and will be followed by Dr. C. Bull, geophysicist, who was also in Greenland for the full two years.

Mr. Hamilton, Mr. Lister and Dr. Bull then read their papers.

The CHAIRMAN: I call on Mr. Stephenson, Reader in Surveying at the Imperial College of Science and Technology, and Instructor in Survey to the Royal Geographical Society, to open the discussion.

Mr. STEPHENSON: This afternoon we have listened to an account of the work of an expedition which is extremely difficult to render. The more successful the expedition, the more difficult the task. After any such venture there are many who are interested to know what the various scientists have been able to accomplish, but the scientists themselves are very loth to give an account of their work until they have really finished it. At any rate, we, as the interested public, have been satisfied this afternoon, but I have no doubt the various contributors feel frustrated at not having been able to tell us all that they did.

In many respects I think the work of this expedition is a pattern of things to come. I have for some time been trying to formulate a general policy for the type of surveying work that a modern expedition might be expected to do, and the account which we have heard this afternoon includes a large number of problems which might well arise elsewhere in the future. Compared with pre-war expeditions the standard of all the surveying has become more precise in that it is being used for other scientific work in which the greatest precision is necessary. The subtense traverse and determination of heights which were required for the gravimetric survey is a good example of this. Exploratory maps of entirely new areas are not likely to form any prominent part of an expedition's survey programme in the future. Nor is an expedition likely to have to make a full-scale triangulation of a new country, but between these two extremes there is a lot of useful triangulation and fixing of points that can be done not only to help the scientists but also to help the national survey, if for example air photographic cover already exists. This expedition has provided some triangulation control to join up with the national survey; it has provided further control so that the national survey can make use of the photographic cover it already has; an extensive and accurate piece of work was carried out to help the gravimetric survey, and finally they produced a very fine large-scale map for the use of the scientists working round the base.

In my mind two things stand out. First the successful subtense bar traverse right across the ice sheet, completed with a very satisfactory standard of accuracy, in what must have been extremely difficult conditions. With this I would include Hamilton's and Brooke's work on refraction. Since the War, with the influx into this country of a certain number of highly trained surveyors from the continent, there has been an increase in popularity of the subtense bar method, and in 1955 the first British precision subtense bar was produced. It is gratifying to note that the bar used by Commander Simpson's expedition was bought for the Society nearly twenty-five years

ago by the late Michael Spender. The second outstanding accomplishment is the detailed 1/50,000 map of the area surrounding the base. This, I think I am right in saying, is the first map ever to be produced by members of an expedition from vertical photographs taken from an expedition aircraft. It was a remarkable achievement to get vertical cover of an area varying in height from 200 metres to 1200 metres from a flying height of 3000 metres when one remembers that the aircraft had to be the type that was used for transport, and capable therefore of flying out from England and carrying 4 tons of equipment at the same time. The expedition and the R.A.F. are to be congratulated on finding a suitable camera, and then installing it in the aircraft—in itself extremely difficult—in such a way that the effect of vibration was negligible. Bearing in mind these difficulties the photographs were very good and enabled Arnold and Brooke to lay down a slotted template assembly from which the control was produced on which they themselves compiled their large-scale map. Mr. Chairman, I have referred to a part only of the survey work of the Expedition, but I am sure others will confirm that the standards achieved are typical of all the work of the expedition, and I do heartily congratulate Commander Simpson and his expedition, and with that I couple the name of their chief scientist, Mr. Hamilton.

Professor GORDON MANLEY (Professor of Geography, Bedford College): I wish to congratulate Mr. Lister on his diagram which demonstrates remarkable facts in regard to precipitation. The elucidation in Greenland of the consequent variation in the annual snow accumulations over a considerable period is of the utmost interest. From the look of his diagram, it strikes one that the range of the annual precipitation is very much the same as we should experience in the British Isles, that is from about 60 per cent. of normal to about 150 per cent. On the other hand, while we can recognize an overall downward trend since 1880 or thereabouts, to perhaps 1940, the changes from year to year are also noteworthy. Hence it would appear that there has been a significant change in the pattern, or energy, of the Arctic atmospheric circulations and this suggests quite a lot of possibilities with regard to the future elucidation in Polar regions of the variations in what might be called the world pattern of weather. I think, too, if I may be allowed to refer to Dr. Bull's work, that elucidation of the character of the moraine material beneath the ice sheet is fascinating, as it may assist us to answer the fundamental questions: how have ice sheets accumulated in the past? From what source? In what way? Certainly there are reasons for thinking that the accumulation might take place from the east side. Such a scheme would be consonant with the theory of an open polar sea at the time when Greenland was first elevated, but obviously we have much to learn yet. I should like to express my congratulations on a fine demonstration of the results of the large-scale work in the field. (See Fig. 6, page 236.)

Mr. G. DE Q. ROBIN (Department of Physics, University of Birmingham): I would like to support Mr. Stephenson's remarks as to the excellence of the work done by the expedition, particularly on the geophysical side. Dr. Bull has not told us anything about the work he did on the gravimetric survey, and as he has also taken over the working up of the seismic results he has a great deal of work to do over the next couple of years. I am very keen to hear more about the gravimetric results from Dr. Bull, because I believe that from this work it will be possible to make some estimate as to how the earth's crust underneath the ice sheet has adjusted itself to the load of the present-day ice sheet. This should give some idea of the long-term stability of the Greenland ice sheet. While the climatic fluctuations about which Mr. Lister spoke are relatively short-term—of ten, fifteen, or perhaps a hundred years—the adjustment of the earth's crust takes perhaps a time of the order of some hundreds of thousands of years. Whether or not the earth's crust underneath the Greenland ice sheet is adjusted to its present load of ice is one of the questions to which I am looking forward to hearing the answer. I asked Dr. Bull that question about six months ago but he was not then ready to answer it.

As regards the technique of seismic shooting, we find that every area appears to

have its own peculiar problems. What I have found in one part of the Antarctic does not apply closely to northern Greenland, nor can we shed much light from northern Greenland onto the problems of the present Trans-Antarctic Expedition. In discussing conditions under the ice sheet we are on very speculative ground, and we could talk about this problem for a very long time. There are one or two possibilities which I will just throw into the bag. One is that if there is a moraine at the bottom of the ice in which the rock density in the ice gradually increases with depth over perhaps 200 or 300 metres, there might not be a sharp interface and very little energy would be reflected. In some parts of the Antarctic I found by using echo amplitudes to evaluate the reflection coefficients of which Dr. Bull spoke, that there was a sharp interface between the ice and rock, since the observed reflection coefficient agreed with the theoretical estimate. Then I wonder whether the line, to the east of which no echoes were obtained, represents the boundary between the unfrozen and frozen portion of the bottom of the ice sheet. If the accumulation to the west is heavier, the bottom is more likely to be frozen and reflection may then be more probable. These are points about which we could speculate for a very long time, but I now conclude by giving thanks for the most interesting information which has been put forward this evening. We shall look forward very keenly to the publication of the final results.

Dr. C. BULL: I think I can reply to some of the points raised. To start with, the results of the gravity traverse made across north Greenland show that, by and large, the crust of the earth is in isostatic equilibrium under the load of the ice sheet. In the centre of north Greenland there is a small free-air anomaly, averaging about −20 milligals, while nearer the coasts it is small but positive. So, to be in complete equilibrium, the land should move up or down only a matter of 100 metres or so. Similar conclusions can be drawn from the gravity results in south Greenland. Concerning other possible reasons for the phenomenon we have observed, namely of having no seismic reflections in the east, and perfectly good reflections in the west, some suggestions have been made. In discussion with Dr. Munk I made the same one as Gordon Robin has just done, namely that in a layer at the bottom of the ice sheet there is a slow variation in density, from ice at the top to moraine at the bottom, and that in this layer no energy is reflected because of the absence of a sharp interface. This is quite feasible. All that is required is that the thickness of the layer should be of the order of three wavelengths, about 200 metres. From existing information it seems unlikely that a layer of such thickness does exist. In any case, by itself this mechanism cannot account for the absence of reflections, since they could still be formed by the moraine-bedrock, or lower, interfaces.

The temperature difference between upper and lower surfaces of the ice sheet is controlled primarily by the rate of accumulation on the upper surface and the amount of heat flowing into the bottom. Mr. Robin suggests that accumulation may be sufficiently different east and west of our demarcation line so that the bottom is melting to the east and frozen to the west. I made a series of Rammsonde profiles along the traverse, and the results show there is no significant variation in accumulation across the line. However, we have no exact knowledge of the geothermal heat, and in the calculation other sources of heat have been ignored. The suggestions I have made to account for our results are extremely tentative so that criticisms and further suggestions will be most welcome.

THE COAST OF SOUTH-EAST ICELAND NEAR INGÓLFSHÖFÐI

CUCHLAINE A. M. KING

THE ROCKY HEADLAND of Ingólfshöfði forms the major hinge point along the long, gently curving, sand bar coast of south-east Iceland. The bar stretches from Vik in the west to Hornafjördur in the east, a distance of 224 kilometres. Ingólfshöfði is virtually an island; a stretch of shallow water, 6 kilometres wide, separates it from the nearest dry land towards the north, while discontinuous sand bars extend away from the south-west and north-east ends. It lies 8 kilometres from the old coast-line,

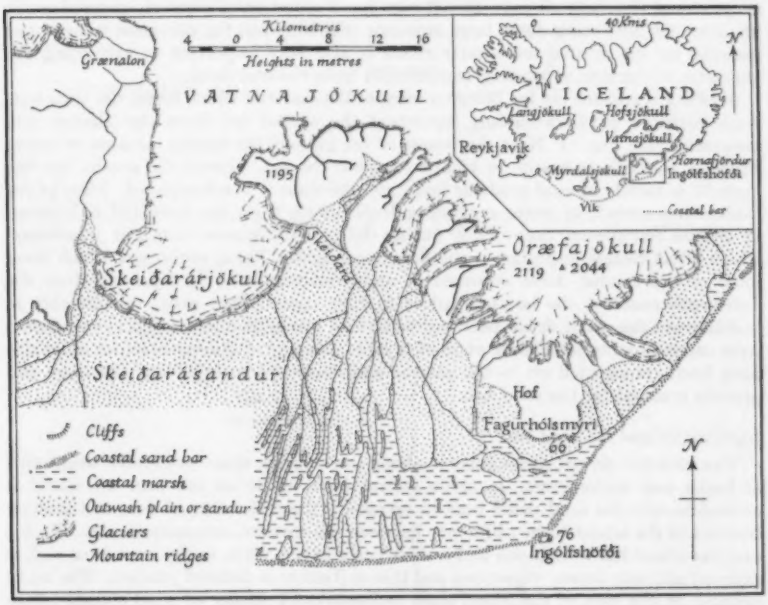


Figure 1

which is shown by the abandoned basalt cliffs of fresh appearance, extending from Hof to a headland east of Fagurhólsmýri (see Fig. 1). It is possible that these cliffs still formed the coastline at the time that the area was first settled between the eighth and thirteenth centuries. Their separation from the sea may be partly the result of a fall in base level but has been mainly by deposition of material in front of them. The cliff top is about 40 metres above sea level and its base about 20 metres so that the cliffs are now about 20 metres high, but they were probably higher at one time. W. V. Lewis [1] has suggested that the coastal bar may have been initiated by a fall of sea level from a post-glacial beach at 40 metres, but according to the Danish Geo-

[1] Lewis, W. V., "Nivation, river grading, and shoreline development in South-east Iceland." *Geogr. J.* 88, 5 (1936) 431–47 (p. 458).

daetisk Institut map the 40-metre contour runs at the top of the cliff near Fagurhólsmýri. Therefore if sea level did fall from this level in post-glacial time it must have initiated first the cutting of the cliffs, not the formation of the bar.

The first historic eruption of Öraefajökull in 1349 caused the outwash plain to build out very rapidly in front of the cliffs. H. W. Ahlmann [1] suggests that this eruption gave the sandur or outwash plain its present day character. There is a story that where the sea was 60 metres deep it became sandur overnight. Although this is probably an exaggeration it does suggest that the sea may have extended to the base of the cliffs before the eruption. The area below the cliffs at Fagurhólsmýri must in any case have been filled in before 1727, when another eruption of the volcano caused farms below the cliff to be ruined by falling ash. This is confirmed by cartographic evidence; Thorarinsson [2] has published a map, produced by Svein Pálsson in 1794, which shows a straight coast in front of the old cliff-line with Ingólfshöfði as an island to seaward, larger than it is at present. Ahlmann has shown that the volcanic eruptions of Öraefajökull have caused very rapid accretion of outwash material as the glaciers melt and bring down large amounts of debris, but the continual transport of material by the normal melt-water rivers is also very important in explaining the character of the area separating Ingólfshöfði from the mainland.

Skeiðará is responsible for bringing most of the material which forms the wide outwash plain of Skeiðarársandur, separating the coastal bar from the glaciers and mountains (see Fig. 1). Near the snouts of the glaciers the sandur consists of coarse material, but this is nearly 20 kilometres from the sea. Nearer the coastal bar the material is mostly of sand grade or finer, and the slope is much reduced. Most of the 6-kilometre stretch of water separating Ingólfshöfði from the mainland is between 10 and 20 centimetres deep. Only during the periodic glacier bursts or *jökulhlaup*, which affect Skeiðarársandur, is the flow appreciable. These outbursts, which flood most of the sandur, have occurred at approximately ten-year intervals since the fourteenth century; the last took place in July 1954.[3] They assist considerably in building out the coast. It has been estimated that 150 million tons of silt in suspension were carried by the *jökulhlaup* of 1938, a large quantity of coarser material must also have been transported on to the sandur and deposited to build out the coast and provide material for the sand bar.

Ingólfshöfði and the sand bars

The island is almost rectangular in shape (see Fig. 2), three sides have steep cliffs of basalt and agglomerate, 40 to 60 metres high, while on the west the island is accessible over the sand drifts banked up against the cliffs. One of the most striking features of the island is the difference between the western and eastern sides. To the east the island has a deep soil and a thick grass cover, while to the west bare rock is exposed and only scanty vegetation and thin soil exists in isolated patches. The rocks exposed on the west of the island show well-marked evidence of wind action, where facets, several feet in length, have been cut. The form of the facets and their distribution seems to suggest the dominance of westerly winds. Two sand bars are attached to the north-west and south-west angles of Ingólfshöfði respectively, extending just south of west. The source of the sand forming the bars is the extensive Skeiðarársandur, lying mainly to the west of the island, although sand is also exposed at the base of the cliffs on the north of the island and on the bar stretching away to the north-north-east. The sand of which the bars are built is composed mainly of basalt glass fragments which make it appear almost black, particularly when wet. Even when it is dry the sand of the bar nearer the sea is darker than the other sand. The

[1] Ahlmann, H. W., 'Iceland, land of ice and fire.' London, 1938 (p. 215).

[2] Thorarinsson, S., 'Vatnajökull,' Chap. XI "Scientific results of the Swedish-Icelandic Investigations 1936, 1937, 1938," *Geogr. Ann., Stockh.*, Årg. **25** (1943) 1–54 (p. 25).

[3] Thorarinsson, S., "Some new aspects of the Grimsvötn problem," *J. Glaciol.* **2**, 14 (1953) 267–75.

difference in colour and angularity of the sands suggest that the two bars are of different origin; the inner one, which is much higher than the other, is wind-blown in origin, while the outer bar is clearly wave-built. The characteristic angularity of the sand grains, specially on the outer bar, can be explained by the short distance they have travelled. The wind-blown sand is less angular because the absence of the protective water film has allowed the relatively soft basalt particles to become abraded

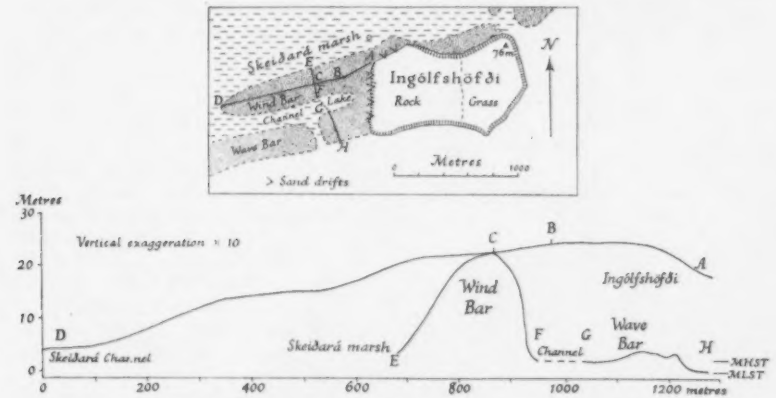


Fig 2. Ingólfshöfði and surveyed profiles; wind and wave bars

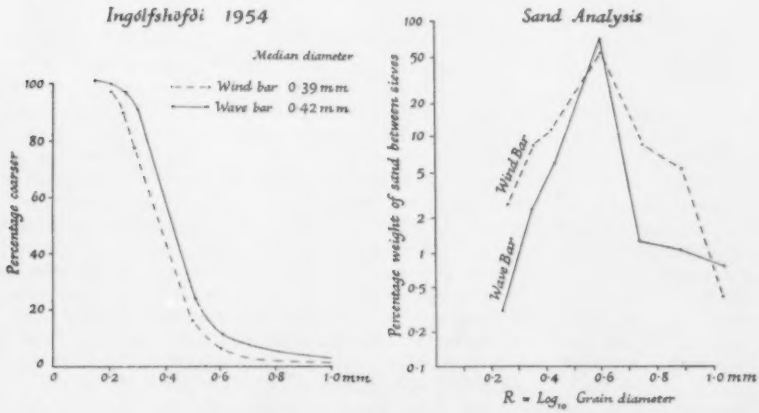


Fig. 3. Analysis of sand from crest of wind and wave bars

to subangular or rounded form. The size distribution of the sand from the two bars is shown in Figure 3. The wind and wave bars are composed of medium grade sand of median diameter, 0·39 millimetres and 0·42 millimetres respectively. The wind-blown sand shows slightly better sorting than the beach sand in some respects. The abrupt bend in the log. curve shown by the beach sand on the coarser side is considerably smoothed out in the wind-blown sand, which has more fine material.

(*a*) *The wind bar.*—All along the cliffs on the west side of the island sand is banked up in the form of climbing dunes.[1] As westerly winds blow towards the island an area of relative calm immediately beneath the cliff would result in the deposition of sand brought from the west. This would gradually build up into a climbing dune. There is evidence of dune bedding in the highest layers, near the cliff top, where the wind could drive sand grains up the slope effectively. The wind bar is much higher than the wave bar. The height is such that it cannot have been formed by the waves and the only force possible is that of the wind. The bar is over 1200 metres in length, extending parallel to the wave bar from the north-west corner of the island. The crest of the bar slopes at a little over 1 degree. This gradient contrasts strongly with the steep slopes across the bar, the seaward slope is about 25 degrees, reaching a maximum of just over 30 degrees, and the landward slope 7½ degrees. The crest is 24 metres above the mean sea level. The bar is composed almost entirely of sand but there are some very thin layers of hardened clay and a few very small pebbles about 2½ millimetres in diameter. The wind bar clearly owes its presence to the existence of the island in whose shelter it is formed. The fact that the wind bar lies parallel to the wave bar suggests that it may be built on the foundation of an earlier wave bar as it would be necessary to form a feature above the level of the sea before wind-blown sand could accumulate. A west wind could bring sand from the exposed wave bar to the west, while winds from the north of east could bring sand from that exposed below the cliffs on the north side of the island.

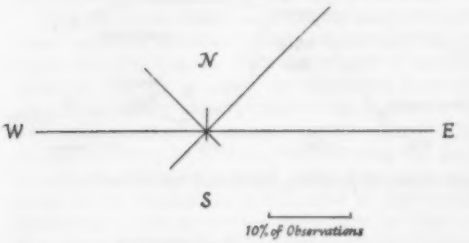


Fig 4. Percentage of winds at Fagurhólsmyri, 1936–45

The wind-rose (Fig. 4) shows the frequency of winds from eight directions at Fagurhólsmýri; this station is situated at the top of the old cliffs under the slopes of Öraefajökull, so that the winds recorded here may differ somewhat from those at Ingólfsöfði. The absence of records of wind strength reduce the value of the observations. The strength of the winds in this area is shown by the faceting of the rocks on the west end of the island and by the rather coarse median diameter of the wind-blown sand and the size of the largest particles in it. West and east winds together amount to 47·5 per cent. of all winds. The sand of the wind bar itself must have been carried largely by winds blowing either from west or north of east, as only in these directions is sand available. These two directions amount to 42 per cent. of all winds. The form of the bar suggests that the dominant dune building wind in the area is from the west, particularly as in this direction most material is available. The crest of the bar would be sheltered from the south-east by the southern end of the island. This would help to account for the variation in gradient on either side of the bar. Northerly winds are more frequent than southerly and would tend to drive sand up the north side of the bar and over the crest to form the steep southern slope. East winds, which appear to be most frequent, probably play a part in shaping the dune to its long tapering form.

(*b*) *The wave bar.*—The wave bar extends for a great distance along the coast in both directions from the island. The profile G—H on Figure 2 was surveyed across the bar, west of the island. Reliable data concerning the tidal range is not available but such information as exists suggests a mean range of 4 feet (1·22 metre) and a mean spring range of 5½ feet (1·67 metre). This is a small tidal range compared to most of the coasts of Britain and is important in explaining the coastal type.

[1] Hack, J. T., "Dunes of the Western Navajo country," *Geogr. Rev.* **31** (1941) 240–63.

Waves reaching the south coast of Iceland may have a long fetch in which long, powerful waves could be generated during storms. The surf is such that stores could be landed on the beaches on only one or two days during the year. The relatively coarse nature of the beach material is another important factor in explaining the type of coast. Because the grade of sand on the beach is fairly coarse the equilibrium gradient would be fairly steep, as a coarser sand is associated with a steeper gradient. The gradient of the beach measured between high and low tide was 1 in 18·5; this is just a little steeper than the minimum to be expected for the same sand size according to Bascom,[1] working on the Pacific coast of America where the tidal range is comparable. He gives 1 in 21 for these conditions. The gradient is, however, dependant on the length and steepness of the waves as well as the sand size, and where this is coarse there is a considerable variation in gradient. The important point is that the equilibrium gradient is in any case very much steeper than the slope of the marsh inland of the bar, which would in the absence of the bar form the coast line. Another consequence of the coarseness of the sand is that it requires a greater wave steepness to produce a destructive effect. Observations have shown that waves of steepness 0·012 are destructive on fine sand, such as that of Rhossili beach in South Wales which has a median diameter of 0·23 millimetre. On coarser sand with steeper slopes, waves must be rather steeper before they become destructive on the beach; on fine shingle, such as that at Abbotsbury on Chesil Beach, waves must probably reach a steepness of 0·017 before they become destructive in character. As a result many of the long swells which must affect this coast would tend to be constructive particularly when the wind is blowing offshore.

The frequency with which winds blow either offshore or alongshore, as shown in Figure 4, is greater than that of the onshore winds. This may help to account for the constructive action of the waves as the wind has been shown to exert a considerable influence on the destructive or constructive action of the waves.[2] This factor may help to account for the apparently destructive action of the waves which were affecting the beach during the observations. These were at first long, nearly 700 feet in deep water, with a maximum breaker height of about 10 feet; they were accompanied by a fairly strong wind blowing obliquely onshore from the south-west. The waves later became shorter and lower, but rather steeper with the wind blowing onshore from the south-east. These waves had cut a small cliff of sand in the seaward face of the bar at high tide level. It is interesting that in the area surveyed the bar extends about 5 feet only above high tide level and the waves tend to swash over it at high water. This is in striking contrast to such shingle features as Chesil Beach on the south coast of England, which extends up to 43 feet above the sea level. The difference may be accounted for by the fact that Chesil Beach is composed of shingle, which becomes coarser as the bank becomes higher, but the coast near Ingólfshöfði is composed of sand. Because it is made of shingle, Chesil Beach is formed by storm waves, which accounts for its height above sea level; the pebbles are thrown up to the maximum limit of the swash. Sand, on the other hand, is removed to deeper water by destructive storm waves instead of being thrown up at the top of the beach. The bar on the south coast of Iceland is therefore probably formed by the action of constructive waves, the sand being derived from the surfeit of material brought down by the glacial meltwater streams. The cliffing brought about by the destructive waves working on the beach during the observations demonstrates that this type of wave does not build the bar.

The bar is an example of an offshore bar built in a region of limited tidal range because the gradient of the offshore zone is flatter than the equilibrium gradient of the type of sand available. The sea therefore uses the surplus material to build up a

[1] Bascom, W. N., "The relationship between sand size and beach-face slope," *Trans. Amer. geophys. Un.* **32**, 6 (1951) 866–974.

[2] King, C. A. M., "The relationship between wave incidence, wind direction and beach changes at Marsden Bay, Co. Durham," *Trans. Inst. Brit. Geogr.*, No. 19 (1953) 13–23.

bar having a gradient suitable to its sand size and the waves acting upon it. On a beach where the tidal range is considerable the beach profile would probably show the development of ridges and runnels under similar conditions. Here, however, the tide is sufficiently small to allow the bar to be built permanently above the still water level. The main essentials for the formation of this type of coast are, first, an abundant supply of material of sand grade, and secondly, an initial profile flatter than the equilibrium gradient, and thirdly, a limited tidal range so that the wave action can be concentrated in a relatively narrow zone and a bar therefore built up above the sea level, by constructive waves, to the limit of the swash at high tide.

Summary and conclusions

The character of this coast can be explained by the interaction of several factors. The part played by these may be summarized as follows:

(*a*) The situation of the rocky island of Ingólfshöfði, a few miles off the solid rock coast, causes it to form a hinge point significant in the general form of the coastal bar. It also provides shelter for the formation of the wind bar.

(*b*) The character of the rocks of the area, largely basalts, is responsible for the type of sand and the ease with which it abrades and therefore the difference in colour and character of the sand of the two bars.

(*c*) The proximity of the large and active outlet glaciers of Vatnajökull ensures that effective erosion is carried on over a wide area, and the rapid weathering in the vicinity is also important in providing much waste material.

(*d*) The powerful melt-water streams carry the material down on to the sandur where it is put at the disposal of the waves and wind. This process is helped by the periodic *jökulhlaup* and the occasional volcanic eruptions.

(*e*) The relatively coarse nature of the sand results in its equilibrium gradient under wave action being steeper than the gradient of the sandur.

(*f*) The waves are responsible for the building of this material into a bar. This process is probably constructive in character, helped by the length of fetch available which would ensure flat waves, these acting on a fairly coarse medium grade sand would tend to be constructive.

(*g*) The limited tide would facilitate the building of a bar above the water level, having the characteristics of an offshore bar.

(*h*) The wind is significant in its effect on wave action and also in its part of forming the large wind bar. This is built by the wind of sand derived from the sandur, but it owes its existence to the sheltering effect of the island and is probably built on the foundation of an earlier wave bar.

The interaction of all these factors explains the development of an offshore bar coast, along which a sand bar separates the sea from a shallow lagoon behind the bar. It is interesting to note that a coastal bar is found along much of the south coast of Iceland; its extent is closely associated with the distribution of the outwash plains of the main ice caps (see inset, Fig. 1) which provide the material of which it is built. Most of the remaining coasts of Iceland are typical fjord coasts.

THE SEARCH FOR THE WHITE NILE'S SOURCE: TWO EXPLORERS WHO FAILED

RICHARD HILL

THE STORY OF the search for the source of the White Nile was brought to an end by the discoveries of Speke and Grant in 1862. The failures—the men who were turned back or who died on the way or who failed through cowardice or incompetence —got less publicity; they paid in silence the price of failure. Two of these explorers, certainly no cowards, died in the Sudan in circumstances which have never been explained: Captain Robert James Gordon, R.N., and an ensign of the Bengal Army, Henry Pyke Welford. There was a third, John Ledyard, whose attempt to uncover the secret of the Nile has already been told in the 'Dictionary of American Biography,' but this young man from Connecticut only got as far as Cairo where he died in 1789 when he was on the point of joining a caravan bound for Sennar.

Gordon was born at Everton in Nottinghamshire, the third son of an infantry captain, and entered the Royal Navy as a volunteer in 1798, the year of Bonaparte's invasion of Egypt. After a brilliant career in the naval campaigns against the French (he was twice shipwrecked and once escaped as a prisoner of war from France) he retired from the Royal Navy in 1815 with the rank of captain.[1] The Association for Promoting the Discovery of the Inner Parts of Africa, briefly known as the African Association of London, which had employed Ledyard, now engaged Gordon who left England, probably at the beginning of 1822, and arrived in Cairo. From here news of the explorer's movements reached London:

> "Captain Robert James Gordon of the Royal Navy left Cairo in May last [*i.e.* May 1822] for the purpose of ascertaining the source of the Bahr el Abiad. He is alone and sets out with a full determination never to return without making some important discoveries. 'If,' says he, 'I should find it advisable for my purpose to travel as the slave of some black merchant, I will most gladly do so, for I feel there is no retreating from what I have undertaken to perform—*en avant* is my motto, and trust to fortune!' "[2]

In a letter to the secretary of the African Association, Henry Salt, the British consul-general at Alexandria, mentioned that Gordon had left Cairo clothed in Arab dress, having learnt enough Arabic to do without an interpreter. Salt was doubtful about Gordon's choice of clothes but did not wish to be dogmatic; "every man prefers his own route to the Temple of Fame." But he added that a Turkish official at Aswan was convinced that Gordon was either mad or eccentric.[3] Gordon was sailing up the reach between Aswan and Wadi Halfa when, on 18 June 1822, another explorer, Adolphe Linant, returning north from a journey in the Sudan, passed Gordon on the river near the rock temple of Abu Simbel. When Gordon told Linant that he was going to discover the source of the White Nile, the Frenchman had doubts, which he recorded in his journal, whether Gordon's mission would succeed.[4] When Linant got back to Cairo he must have spoken to Salt about Gordon's eccentric ways. Salt could not help thinking that Gordon's Arab shirt would expose him unduly to sun and night damp. Though he had authorized Gordon to draw on him for any reasonable sum,

[1] Marshall, J., 'Royal Naval Biography,' 1833, Vol. 4, pt. 1, pp. 201–2.

[2] *Quarterly Review*, **28** (1823) p. 93.

[3] Salt, H., to Colonel Leake, dated Alexandria, 22 September 1822 (J. J. Hills, 'Life of Henry Salt,' 1834, Vol. 2, p. 211).

[4] "Journal d'un voyage en Éthiopie dans les années 1821 et 1822." MS. in the Ashmolean Museum, Oxford, entry for 18 June 1822.

which would be refunded by the African Association, he feared that the explorer would not be able to go far beyond the furthest Egyptian outposts which were then only a few miles upstream of Khartoum. He had given Gordon letters to 'Abidin Kashif, the kindly governor of Dongola, and to Isma'il Pasha, Muhammad 'Ali's son, then commanding the Egyptian troops in Sennar, who was shortly to be killed by the Sudanese tribesmen at Shendi.[1]

Two days after Gordon had parted from Linant he met Frédéric Cailliaud, another French traveller, who had attached himself to Isma'il's army. The two men met off es-Sabu'a. Cailliaud remarked upon the Captain's austerity, how he submitted himself, perhaps rashly, to the hard, Arab way of life, wore only sandals and a shirt, and plunged from his boat at all hours to swim in the river.[2]

At Berber Gordon again flouted the conventions of European travel in Africa; he sent his servant Mahmud back to Egypt and decided to go on alone. And alone he went to his death. After Berber all authentic traces of Gordon's movements are lost. He is said to have visited the mountain regions of Kordofan where he fell ill of a tertian fever. George Hoskins, picking up the threads of the evidence in Dongola and Berber eleven years afterwards, wrote that he had gone via Dongola to Kordofan where he had offended the governor, Rustam Bey, by offering him a trumpery present. He had then, according to Hoskins, travelled across country to Wad Medani where he died.[3]

Lord Prudhoe, the future Duke of Northumberland, who made a journey to Sennar in 1829 and passed by Wad Medani, reported that Gordon had arrived there ill about June 1821 and had died of violent tertian fever in ten days. He was buried in a spot set apart for Christian dead. All his effects, wrote Prudhoe, were taken by Bozzaris, Isma'il Pasha's Greek *protomedico*, and were most probably lost when Bozzaris was murdered along with his master at Shendi. As the massacre at Shendi took place in the latter half of October 1822—the exact date is uncertain—Prudhoe's date for Gordon's death seems to have been a mistake for "about June 1822."[4] The present writer made a thorough search in and round Wad Medani for traces of a Christian cemetery dating back to the early days of the Egyptian régime, but found none. Another informant, reporting at second or even third hand, stated that Gordon died at "Wilet Medinet" on 27 September 1822 "on his way to Sennar."[5] Another related that Gordon was accidentally drowned while bathing "about July 1822." The absence of news of him from the Sudan was evidently worrying the British consul-general, for in August 1823 Muhammad 'Ali Pasha issued a circular to province and district officials "and all other persons stationed between Cairo and the Sudan" announcing that nothing had been heard of Gordon and ordering that, if he were found, he should be sent back to Cairo.[6] But he was never found.

The end of Henry Welford was even more mysterious. He was a Wiltshireman, born at Marlborough in 1808. His father was a local lawyer who built the house, afterwards called Wye House, which is now part of the Marlborough Grammar School. In 1826 Welford was entered as a cadet in the Indian Army. An ensign in 1827, he was posted to the 30th Bengal Native Infantry, but for some unknown reason

[1] Salt to W. Hamilton, dated Alexandria, 11 September 1822 (J. J. Hills, *op. cit.*, p. 205). Salt's biographer added a smug footnote recording that Gordon met the fate that Salt had predicted.

[2] 'Voyage à Meroé,' 1826, Vol. 3, p. 267.

[3] 'Travels in Ethiopia,' 1835, pp. 180–81.

[4] *Jour. Roy. Geogr. Soc.*, 5 (1835) p. 47.

[5] *Scots Mag.* 15 (1824) 639. See also *Gentleman's Mag.* 94, 2 (1824), p. 574, and 95, 1 (1825), p. 478. The year of his death is given as 1824 in C. O. Skelton and J. M. Bulloch, 'A biographical muster roll of officers named Gordon.' Aberdeen, 1912, pp. 293–4. An obituary appeared in *Bull. Soc. Geogr. de Paris*, 3 (1825) 152.

[6] Egyptian State Archives, Palace of the Republic, Cairo, *ma'iyet-i seniye*, Turkish bureau, letter book 11, No. 838 (Arabic), 25 August 1823.

he resigned his commission in 1828 and came home. Geographers in the West were at this time sharply divided in their opinions on the location of the source of the White Nile. Some held that the river flowed out of south-western Abyssinia somewhere south of the Sobat which had been reached by an Egyptian raiding column under Khurshid Agha in 1827. Others, reading reports from explorers and traders in Dar Fur, placed the White Nile springs far westward in the middle of Africa. The African Association wished to test the second theory and on 23 March 1830 Sir John Barrow, secretary to the Admiralty, who had done so much for geographical discovery, wrote to Mr. Backhouse of the Foreign Office:

> "Mr. Henry P. Welford is engaged by the African Association to proceed to Egypt, from thence to Sennar, and from thence along the southern bank of the Bahr El Abiad as far, if he can, as Bornou which there is every reason to believe he will be able to do with the aid of Mohamet Ali's officers stationed in that neighbourhood. . . . Would you have the goodness to ask Lord Aberdeen for a letter of introduction to the Consul-General through whom he may procure a Firman from the Pacha without which it would be vain to attempt the journey. He is a fine young man, has travelled overland from India and knows Arabic. He embarks on Thursday next."[1]

On the next day the Foreign Secretary signed a letter, drafted in almost identical language, to the consul-general at Alexandria.[2] Welford landed there in June. Barrow's letter shows how little was known in London, even in the most informed geographical circles, either of the interior of Africa or of the course of the White Nile. The man who proposed to lighten the darkness was twenty-two years old. His experience of a journey "overland from India" which may have been nothing more ambitious than a journey overland from Suez to Alexandria over the route which Lieutenant Waghorn was soon to open for regular travel, and his reputed knowledge of Arabic which can have been but small, were light equipment for the heavy trials ahead. A firman issued by Muhammad 'Ali Pasha on 1 July 1830 requested the usual facilities from Egyptian officers on the route for "Mr. Wilfurth, English traveller, going as far as Sennar."[3] Why Sennar and no further? Discretion may have moved the British consul-general to reticence in the wording of his request to the *vali* for a firman on Welford's behalf; it is more likely that the Egyptian authorities well knew that beyond the province of Sennar no firman was of the slightest use. The infidel does not read firmans.

As in the case of Captain Gordon, darkness came down the moment the explorer left the well-navigated reaches of the Nile. Almost our only source of information for the next stage of Welford's journey is a paragraph in the *Bulletin* of the Societé de Géographie of Paris to the effect that "M. Vilford," undeterred by the fate of his predecessors, was on the way to attempt to penetrate into the interior of Africa and, thirty-seven days after landing at Alexandria, had crossed into Nubia. The journal goes on to state that Welford had hoped to have with him several of his fellow-countrymen who were then in Egypt, but a war between Muhammad 'Ali and Abyssinia had forced him to set out alone. Muhammad 'Ali had advised him to travel by way of Dongola and the Bayuda Steppe to Kordofan, but he was delayed on the way by intermittent fever. The latest letters from Egypt indicated that he had almost regained his health and intended to go in a few days by camel beyond the Second

[1] Public Record Office. FO. 78/192. The African Association was not very active during this period and in 1831 was amalgamated with the Royal Geographical Society which ignored Welford's mission in its journal and proceedings. The proceedings of the African Association at this time are not in the archives of the R.G.S. and appear to have been lost.

[2] Lord Aberdeen to Consul-General Barker, 24 March 1830 (FO. 78/192).

[3] Egyptian State Archives, *ma'iyet-i seniye*, Turkish bureau, letter book 42, No. 13. Rescript of 1 July 1830.

Cataract. The journal added that Welford was apparently trying to reach Timbuktu by way of Kordofan, a route which no other European had up to then attempted.[1]

We do not know, and the *Bulletin* does not tell us, where it got its information. Vague though it is, it is our last advice of Welford alive. Nothing more was heard of him until the news of his death reached England when *The Times* of 20 June 1831 contained the following mangled obituary:

> "Captain Woodfall. We regret to announce the death of another African traveller. Captain Woodfall, sent out by the African Society to penetrate into the interior by way of Abyssinia, only reached Kourdefan where he fell sick and perished."

The *Gentleman's Magazine* also had a brief notice which looks like a butchered borrowing from *The Times*:

> "May. . . . At Kourdefan in Abyssinia, Capt. Woodfall, who had been sent by the African Society to penetrate into Africa through Abyssinia."[2]

How the information came to England is not stated, and the British consular papers are silent on Welford's death. A Bohemian trader, Ignaz Pallme, who travelled in Kordofan in 1838–41, wrote in his book that "Woodfall" fell a victim to the climate of that province.[3] In a letter to one of his officers Muhammad 'Ali wrote that the English traveller "Wilken" had died in Dongola and that his kit should be returned to Egypt.[4] Egyptian official correspondence was often vague on places and place names, and it is unlikely that the Cairo Government would have been kept accurately posted with news of the traveller's itinerary stage by stage.[5]

FROM THE *JOURNAL* A HUNDRED YEARS AGO

THE FOLLOWING ABSTRACT is taken from W. Kennett Loftus' "Notes of a Journey from Baghdad to Busrah, with descriptions of several Chaldaean Remains," read to the Society on 10 March 1856 and printed in the *Journal of the Royal Geographical Society*, Vol. 26, pp. 133–53. A modern view of the same area and people may be found in Wilfred Thesiger's paper "The marshmen of southern 'Iraq" (*Geogr. J.* **120** (1954) 272).

"*Jan.* 1, 1850.—The new year commenced with a bitter disappointment to my companion and myself. We had fully calculated on spending the first day of the year upon the ruins of Nufr or Niffar, the ancient Babylon of Sir H. Rawlinson, and we had made a long journey the day previously for this purpose.

[1] *Bull. Soc. Géogr. de Paris* **15** (1831) 194. The reference to a war between Muhammad 'Ali and Abyssinia is baffling. Though there was continual fighting among the frontier tribes, war in earnest between Egypt and the Abyssinian rulers of the border provinces did not start till 1836, and this was not Welford's route.

[2] *Gentleman's Mag.* **101**, 1 (Supplt.) (1831), p. 651. The name Kordofan was sometimes used as a synonym for El Obeid, the seat of the governor of Kordofan. I have found no trace of Welford at El Obeid. As for "Abyssinia," the writer of the obituary evidently confused it with Ethiopia, a region which some travellers extended to Kordofan.

[3] 'Travels in Kordofan,' 1844, p. 192.

[4] Egyptian State Archives, *ma'iyet-i seniye*, Turkish bureau, letter book 41, No. 526, 12 January 1832.

[5] I am grateful to Mr. E. G. H. Kempson of Marlborough College and Miss A. Thompson of the India Office Library for guidance on Welford's parentage and Indian career.

"Our worthy host represented the way to the ruins as beset with innumerable difficulties and dangers; but, finding us to be stern in our resolve to overcome them, he yielded a reluctant consent that his son and a few horsemen should accompany us. After riding for upwards of an hour in a dense fog we discovered that we had been led a complete circuit round the camp! An angry parley ensued, as it was evident that our guides had received instructions to prevent our reaching the ruins. We therefore determined on giving up the attempt for the present, and insisted on being conducted to Shkhiyer. Slipping and sliding about in the mud and water of an extensive marsh, we reached that place in another hour.

"Shkhiyer is a place of considerable size, situated on a narrow peninsula of low land, almost surrounded by the marsh. The huts are wholly constructed of reeds, which are tied in large bundles and neatly bent archwise. They are covered externally with thick reed matting, through which rain has some difficulty in penetrating. The muthíf, or reception hut of the Sheikh, is about 40 ft. long and 18 ft. high, blackened in the interior with the smoke and soot of years, which have no other vent but the one entrance at the extremity facing the marsh. Numerous huge reed-baskets, containing grain, indicated the comparative wealth of their owners. The manly and expressive countenances of the inhabitants, and their remarkable partiality for bright-coloured clothing, proclaimed them to be of a different caste to the Zobeid. They subsist chiefly on the rice produced by the marsh-land, which, at the season of our visit and for a third of the year, is entirely covered by inundation.

"The Shkhiyer is a division of the Affej tribe (Sheikh Aggab), whose residence is among the marshes which extend from the Euphrates, near Diwanieh, eastward into the very heart of the Jezireh, and southward to the Shat-el-Kahr. The whole Affej tribe numbered about 3000 families, whose annual tribute to the Pasha's treasury amounted to 100,000 piastres, or upwards of 900*l*. The Pasha had, we understood, announced his intention of doubling that amount for the ensuing year. The tribe was consequently in no slight state of fermentation, and complained bitterly of the treatment they had at various times experienced from the governors of Baghdad. Nedjib Pasha had thrice cannonaded the fragile town.

"Communication is maintained with other places by means of long sharp-pointed boats, or canoes, called "terrádás," which are constructed of Indian teak, measuring from 12 to 14 ft. in length, by about a yard in width at the broadest part. They are propelled at a rapid pace through the shallow water by means of long poles.

"We spent the afternoon upon the marsh and in making preparations to reach Niffar on the following morning. Nothing could exceed the hospitality and kindness of old Sheikh Shkhiyer, his sons, and the whole tribe; but there was an evident disinclination towards accompanying us to the ruins. Before quitting Baghdad we were told that the Arabs would throw innumerable difficulties in our way, and, if possible, thwart our object. They were certainly very suspicious of our intentions, and could not be persuaded to believe that we merely wished to see a number of shapeless and barren mounds. They imagined that we must be in search of the treasure which Arab report says is deposited there."

A NEW SOVIET WORLD ATLAS

ATLAS MIRA. *Moscow: Glavnoye Upravleniye Geodezii i Kartografii, M.V.D., S.S.S.R.*, 1954. 20×13½ *inches; 253 pages.* 16 gns.

ALL TOO FEW cartographic publications from the Soviet Union are obtainable in the western world, and those that do manage to filter through the "official" agents for communist publications are generally teaching aids in the form of wall maps and middle school atlases, rather than the detailed works which the serious student of the geography of the U.S.S.R. requires. It is therefore gratifying to note the arrival in the United Kingdom of what is possibly the finest example of Soviet cartography so far to appear. The 'Atlas Mira' is a world atlas of international stature, a class which Mr. Crone, in reviewing the first volume of the new 'Times Atlas,' noted as containing very few examples. The work involved in producing such atlases is enormous, even when the basic plates from earlier editions are available, as is the case with the 'Times' and "Touring Club Italiano' (T.C.I.) atlases. Likewise the cost is enormous (an American report puts the cost of the new edition of the 'Times Atlas' at some £750,000), and can only be met by richly-endowed organizations, or Governments themselves. It would appear, however, that only the full weight of government support can in these days bring about the publication of a wholly fresh world atlas appearing as a complete entity rather than as a collection of parts issued over a number of years. The advantage to the serious student of an atlas with a short basic period of compilation could perhaps be overrated but cannot be ignored.

The 'Atlas Mira' was published in 1954 by the Chief Directorate of Geodesy and Cartography (G.U.G.K.) and is the result of coordinating the work of a number of cartographic establishments within the state organization. The editing of the Atlas as a whole was completed in mid-1953, although for some plates it was considerably earlier, as can be deduced from the fact that the printing of the plates was spread over the period June 1952 to April 1954. Twenty-five thousand copies were printed, and the size of the issue should encourage many of our large libraries to pursue copies. The price in the Soviet Union of about £40 appears rather high, but with the more realistic export exchange rate applied by the Russians to their publications the cost in England of 16 guineas makes it a sound investment which no library committee should overlook.

The maps in the Atlas are arranged in continental groups preceded by a few world maps. In each main group the sequence is similar. As an introduction to a group there is a general physical map (1 : 10,000,000 to 1 : 25,000,000), followed by communications and political maps. This is followed by a number of general regional maps (1 : 1,500,000 to 1 : 7,500,000) which are supplemented for important areas by larger scale maps (1 : 250,000 to 1 : 750,000). The 283 pages of maps contain 261 separate maps, which are well distributed over the various continental groups, with some emphasis on the Soviet Union, as is to be expected (57 maps in 76 pages).

The majority of the maps are printed with layer colours in what one might call the "classical" range, *i.e.* dark green/light green/buffs/browns, with a blue scale for water depths. Some of the regional maps have in addition a purple hill shading. In general the effect is pleasing and expressive. The tonal density scale employed lends itself to use at different map scales with considerable success. A few of the maps have relief expressed solely by a simple form of hill shading, which is economical but useful.

Hitherto little has been known about the official Russian attitude on the question of transliteration of foreign names into Russian script. An examination of various publications shows that a number of systems have existed at various times in different spheres of activity. The theoretical position is now considerably clarified by the introduction to the companion volume,"Index to Place Names," to which all pur-

chasers of the Atlas are entitled. The rules governing the treatment of names in the Atlas deserve a full consideration which will not be attempted here. Suffice it to say that there is a system given which is rational and in most cases unexceptionable from the point of view of geographical names experts. The rendering of foreign names in Cyrillic script should not be considered as a complete bar to the fairly wide use of the Atlas by reasonably intelligent people armed with a knowledge (and a copy) of the Permanent Committee on Geographical Names (P.C.G.N.) system of transliteration for the Russian alphabet.

Some difficulty may be experienced at first with the smaller sizes of type used which benefit from enlargement with a magnifying glass, but the type is well cut and clearly reproduced. Indeed, the use of small typefaces is sometimes the subject of acrimonious discussion, but one can justly say that in a reference atlas the maximum number of names consonant with overall cartographic clarity is a prerequisite. Some of the plates in other world atlases go to the other extreme. On the use of small type it is interesting to compare the maps of Iceland and Denmark in the 'Atlas Mira' with the corresponding maps in the 'Times Atlas' and the new 'T.C.I. Atlas.' The 'Atlas Mira' version of Iceland is an exquisite example of small type lending itself to economy of scale while retaining clarity and detail. With slightly fewer names than the 'T.C.I. Atlas,' its use of blue for water names gives it a far less heavy appearance. In the representation of relief the 'Atlas Mira' version of Iceland with its layers and hill shading is superior to that in the 'T.C.I. Atlas' and scarcely less successful than that in the 'Times Atlas' at two and a half times the scale. At the larger scale, however, the 'Times Atlas' has the advantage over both of the other atlases in numbers of names and presentation of the communications network.

A point of general interest is raised in considering communications. The 'Times Atlas' has three generally applied categories of roads, *i.e.* special roads (Autobahnen); arterial roads; and other main roads. The 'Atlas Mira' has super-highways and main motor roads; other metalled roads; and earth roads or tracks. The 'T.C.I. Atlas' has three unspecified categories of road. The differences in classifications of roads found in comparing the three atlases must reflect the difficulty the various nations' cartographers have in visualizing the types of road that are normal in other countries. Thus the Russian differentiates primarily between metalled and unmetalled in the knowledge that many of his native main roads will be in the latter category. The British cartographer almost inevitably misinterprets the importance of another country's dirt roads because he lives in an environment laced together with metalled roads almost entirely. Thus a dirt track across the Sahara becomes a main road for lack of competition in the area, the same term as is applied to a well constructed main road in, say, southern England or the Ruhr. The Russian on the other hand is at a loss in compiling, say, the Denmark sheet; with a vast number of "other metalled roads" to choose from, the compilation exercise results in a very sparse unbalanced network. What seems to be required at atlas scales is the admission by map-makers that one man's dirt track is another's main highway, and that they should not try to apply a few highly coloured terms universally.

Finally, what does this new Russian Atlas tell us about the Soviet Union? The answer is undoubtedly—a great deal. Much significant detail may have been left off the plates on security grounds, but it is unlikely that such a magnificent piece of cartography should be considered by the Russians as a suitable vehicle for putting over deliberate errors and distortions for western consumption. It can be assumed that the great changes in detail and topography as between the plates of Vol. II of the Great Soviet Atlas (1939) and the corresponding plates of the 'Atlas Mira' reflect the known progress of new accurate topographic surveys over much of the Union which was either unmapped before the war or covered only by the basic mapping of the Tsarist period. Other changes indicate the devastations of the last war and also the tremendous construction and reconstruction which has been achieved since the war. Thus the new lake in the middle Don is shown which resulted from the work

on the Volga–Don Canal, and in Asiatic Russia new settlements and communications indicate the developments which are taking place there.

The Atlas is printed on good quality paper. The plates are mounted on rather narrow single linen guards well bound into heavy board covers. (Cf. the 'Times Atlas' where the slim volume III has its sheets mounted on broad double linen guards, and the 'T.C.I. Atlas' where the sheets have strong linen guards maintained in a very heavy but undoubtedly durable steel-cored loose-leaf binder.) The separate index to place names is in a smaller format and contains some 205,000 names and a short but useful glossary of non-Russian geographical terms. Place names are located not by geographical coordinates, as in the case of the 'Times Atlas' Index, but only by plate number and arbitrary grid reference, which the latter also gives.

The pre-war 'Great Soviet Atlas' provided many geographers with the material for articles and books on the Soviet Union. The 'Atlas Mira' will undoubtedly be an indispensable standard work for present-day geographers in the Western world.

IAN MUMFORD

THE FACE OF ROMAN BRITAIN

MAP OF ROMAN BRITAIN. Third edition. *Chessington, Surrey: Ordnance Survey*, 1956. *Map and text: folded*, 11 × 8½ *inches, open*, 39½ × 30½ *inches; text* 43 *pages.* 7*s* 6*d; map only*, 3*s* 3*d; text only*, 3*s*

A QUARTER OF A CENTURY has passed since the second edition of this rightly celebrated map was published; a period, as a glance at this new edition will show, of remarkable activity in Romano-British archaeology, both on the ground and from the air. For this edition, the scale, at 1/1M, remains unchanged. But if discoveries continue at the present pace, the next edition will certainly require a larger scale, and possibly separate maps to illustrate the different periods of Roman rule.

There are a number of aspects of this new edition which will be of special interest to geographers. First of all, a new base map has been prepared and this is to serve for a whole series of historical maps up to the eighteenth century. Great Britain is now covered by a single sheet. This shows not only the territories, Ireland and the highlands of Scotland, which escaped Roman occupation (and the benefits of the Roman inheritance) but also the coast of Gaul around Boulogne; this was the base area for the Claudian bridgehead, the base for the "British" fleet (the *Classis Britannica*), and the linking territory with the heart land of the Empire. With so much on one sheet, one can see at a glance the broad strategic and tactical plan, and follow the unequal progress of Romanization. The importance of the close attachment of the Regnenses of Sussex as a secure base for the westward advance against the Belgae; the obvious need to subdue Wales to protect the left flank of an advance into Scotland; the prevalence of forts and the comparative absence of "villa" sites in Wales showing that military occupation and not Romanization was here the only answer to an implacable people; these are only a few of the lessons of history which can be drawn from the map.

Looking more closely at this new edition, there are a number of developments which geographers will be glad to see. Natural woodland is no longer shown on a geological basis. It is omitted altogether; partly because so much woodland must have been cut down in Roman times but, more important, because it is now evident that the boulder clay areas of counties like Essex, Suffolk and Norfolk do not necessarily exclude loamy soils prized by the Romano-British farmer. The Roman canal system in the east of England is now shown for the first time. This would have given much pleasure to the late Major Gordon Fowler to whose persistent researches in

the Fenland much of our knowledge is due. Finally, the so-called "Celtic" field system (introduced in the late Bronze Age) is also shown, though in patches in the south and east only. This seems over-cautious, even in a publication which, of its nature, rightly spurns speculation. The system might well have been extended to Wales and elsewhere, for which reliable evidence exists; or alternatively, excluded altogether on the grounds that, because of widespread ploughing or building, no compehrensive representation of the areas covered by this particular type of peasant agriculture could ever now be shown.

So long a time has elapsed since the last edition of this map that it is also worth glancing at the principal archaeological changes and additions. Following the headings of the admirable introductory text, there come first of all the new military sites revealed (largely through the enterprise of Dr. St. Joseph) by air photography and often confirmed by excavation. The outstanding addition here is Inchtuthil, the Roman *Pinnata Castra*, the northernmost legionary fortress of the Roman world. Beyond it, following the line of Agricola's advance and stretching into the remoter parts of Aberdeenshire, are a series of advanced forts and temporary camps. The angle of this line of advance from the frontier across the foothills and coastal lands looks almost as if it was reflected in the curious angle at which Scotland, in relation to Albion, lies in Ptolemy's map.

Another lesser but interesting class of military site now shown for the first time are the works constructed for battle exercises and manoeuvres. Among the urban sites, cantonal capitals are now distinguished by a special symbol, as are the spas at Bath and Buxton. In the countryside, the most striking feature is the great increase, outside the military zone, in the number of estates and villas, homes of the landed gentry or of industrial magnates. The distribution is, of course, not uniform but their scarcity in some areas may be due as much to the vagaries of archaeology as to differing degrees of "civilization." Two other interesting additions are the aqueducts in Dorsetshire, Lincolnshire and elsewhere and the two lighthouses at Dover. One wonders whether the gigantic monument of imported Carrara marble at Richborough might not also have served as a lighthouse. Certainly on a fine day, the great gleaming statue of (probably) the emperor, crowning its unnumerable marble tiers, must have been a landmark visible far out to sea.

A chronological table, a description of the chief literary sources such as the Antonine Itinerary, and two most useful indices of topography and of Roman place-names complete this scholarly and elegant publication. Five maps are included in the introductory matter, to illustrate special areas or problems. It is a pity that to these could not have been added one to illustrate Hadrian's wall which must nearly be the most intensively studied frontier zone in the whole Empire.

Only those who know what an immense amount of work has been done and published on Roman Britain in the last twenty-five years, will appreciate the careful and laborious investigations which the anonymous editor of .this map has had to carry out. Used in conjunction with Professor Ian Richmond's small book,[1] recently published, on Roman Britain, it brings the fruits of the latest scholarship within easy reach of all.

At the same time, the amount of new information on the map reminds one sharply of the need for similar maps of other, and more important, territories within the Empire. Egypt, one of the two great granaries of the Roman world, a country highly prized and jealously guarded by successive emperors, is a case in point; a country where archaeology, despite political upheavals, continues to thrive and has produced a great deal of new information which does not appear on the Egyptian sheet of the International Map of the Roman Empire.

A revision of this sheet is especially important for the southern frontier zone of Egypt (the southernmost of the Roman frontiers) which, incidentally, provides some interesting comparisons with its northernmost counterpart in Britain. Both were

[1] Richmond, Professor Ian, 'Roman Britain,' London, Pelican Books, 1955.

exposed on their flanks to the swift strikes, and swift withdrawals, of raiders possessing all the advantages of mobility across the seas in one case, and across the deserts in the other. In both cases, under Caracalla in Britain and under Diocletian in Egypt, advance defences were withdrawn for consolidation along geographically stronger and more economical lines, and tribal *foederati* were then enrolled to form buffer states to fill the gap and to give defence in depth. A study of both frontiers in their earliest forms gives point to Professor Lattimore's axiom that frontiers are of social and not of geographical origin.[1] In Britain, the distribution of the Votadini spreading over Lothian and Northumberland, was probably a more important basis for deciding the position of the northernmost Roman frontier than any feature of physical geography. The subsequent enlistment of the Votadini as Roman allies, marked by their use of Roman titles and names, brought Northumberland at least within the Romano-British sphere of influence. It may provide an historical background for the ultimate inclusion of Northumberland among the territories south of the "Border."

L. P. KIRWAN

REVIEWS

EUROPE

HOLIDAY LANCASHIRE, by SYDNEY MOORHOUSE; THE WIRRAL PENINSULA, by NORMAN ELLISON; THE SOLWAY FIRTH, by BRIAN BLAKE. Regional Books Series. *London: Robert Hale*, 1955. 8½×5½ *inches*; viii+227, x+264, *and* x+230 *pages; maps and illustrations.* 18*s each*

These three books are part of a regional series which supplements the earlier and well-established series of County Books. The authors have been freed from the limitations imposed by artificial boundaries, and the works should, therefore, mean rather more than some of their predecessors from a geographical point of view. Unfortunately, the validity of the conception as regions of two areas discussed here is open to doubt, but this does not depreciate the actual contents of the respective books to any great extent. None of them are text-books, many of their pages being devoted to local legends and personal recollections, but the Lancashire and Solway volumes at least present synthesis of all types of information which amount to admirable area studies. The regional ties may be vague and much of the material might appeal to the general rather than the specialist reader, but there is a lot to be said for a treatment which recognizes no artificial barriers between the various academic disciplines.

The so-called Lancashire holiday area is dealt with piece by piece in a series of separate studies. These do nothing to strengthen the case for calling the area a region —rather do they show that it is the sub-divisions (Little Fylde for example) which have the better claims to regional designation, but in themselves they are very good. In all of them the author stresses the importance of the people. One feels he knows them, and this is most important where they form so integral a part of the landscape as at Blackpool and Southport—both very much that type of artificial feature which Mr. Moorhouse seems to know just as well as he knows the marshes and the sands. He may feel more at home on the latter, but he appraises greatly contrasting areas equally well and without bias.

If Mr. Moorhouse knows the permanent and seasonal residents of the Lancashire area, Mr. Ellison certainly knows the people of his Wirral. But his book is only an itinerary punctuated by personal reminiscences. A lot of things have happened in the

[1] Lattimore, Owen, "The frontier in history." *X. Congresso Internazionale di Scienze Storiche, Relazioni*, vol. 1, 105–138, Florence, 1955.

Wirral, and these are described attractively enough, but there is no discernable plan to the book, no patterns emerge as one reads, and explanations are almost completely lacking. There is undoubtedly a market for this type of book, but to a geographer it seems that there must be a better way of looking at the Wirral—particularly as the regional ties here are more distinct than on either the Lancashire Coast or the Solway. Mr. Blake, the author of the Solway Firth volume would probably disagree with this last statement—at least as far as his area is concerned, for he seems to feel an essential unity over the estuary. I cannot agree that this is real. It may have been at times in the past, but one feels that the man-made line between England and Scotland is more significant than this book suggests. Nevertheless, it is a very good book in which the author overcomes the problem of limited space in an interesting fashion. There is no attempt to deal fully with agriculture, fishing or industry. Instead, the emphasis is laid on the local peculiarities of each. The book, therefore, is not a complete study, but is an admirable introduction to the Solway which can easily be supplemented by other reading, simply because the systematic approach is fundamentally sound.

N. H.

ENTWICKLUNG UND WESEN DER HAUPTSTÄDTE DER ÖSTERREICHISCHEN BUNDESLÄNDER. By Dr. HERBERT PASCHINGER. *Innsbruck: Universitätsverlag Wegner*, 1954. $9\frac{1}{2} \times 6\frac{1}{2}$ *inches;* 88 *pages; Sch.* 54

Dr. Paschinger summarizes the geographical and historical factors influencing the evolution of each of the eight towns (including Vienna) which are centres of Austrian provincial government. Considerable emphasis is placed on their importance as route centres and comparisons are made with alternative centres and past rivals for the establishment of the governmental function. Of particular interest are his references to recent changes in economic life and the increasing significance of tourism as a source of income and employment. Excellent sketch maps and a short bibliography for each section complete this up-to-date study in urban geography. H. T.

ASIA

FAUNA AND FLORA OF NEPAL HIMALAYA. Edited by H. KIKARA. *Kyoto University, Japan: Fauna and flora research society*, 1955. 10×7 *inches;* v, 390 *and* x *pages; maps and illustrations*

One of the most difficult things to do after the close of an expedition devoted to biology is to write up the complete results—and publish them. The accurate identification of species is becoming increasingly difficult, for today the type specimens may be anywhere in the world. There is also the financing and production of a book which is something more than a mere list of names. The time varies with the varying factors; but in this country it is now generally reckoned in years, if not in decades Thus one cannot but admire the Japanese naturalists for the astonishing feat of producing a book on the natural history of Nepal, within eighteen months of their homecoming; and this including two seasons of intensive exploration. It is an example of enviable cooperation on the part of authors and experts on the one hand, and of technical staff on the other.

Objective criticism of the work is another matter. The book bears the marks of hasty preparation, as though the main object had been to produce *something* quickly, in order to anticipate others known to be working in the same field. Here the spectacle of international rivalry raises its blunt head. At least three British expeditions to Nepal, between 1949 and 1952, have amassed a large collection of plants and seeds—but not, it must be confessed, much else. The fact that they covered most of the ground covered by the two Japanese expeditions, as well as much other ground, is one, but not the only reason why their botanical work has not yet been published and coordinated—although, of course, preliminary reports have appeared in several journals. This, however, is no less a criticism of the slow British approach than of

the dynamic Japanese thrust. The book, however, deals with other subjects besides plants. There is a good account of the butterflies collected, with many excellent photographs (not in colour); and British authorities like Colonel F. M. Bailey and Colonel D. G. Lowndes are given full credit for their earlier work. Small collections of dragonflies and mayfly nymphs are also dealt with.

However, as two-thirds of the book is devoted to botany, it is mainly on this that the book should be judged. On the whole it comes well out of a close scrutiny. There are misprints amongst plant names, but the botanist will not be misled by them; and since the book is written in excellent English, one can only marvel at how few they are—fewer than in an issue of the *Journal* of the Bombay Natural History Society, for example. Some of the thirty-three new species of Angiosperms described are of doubtful validity, *e.g. Lonicera minutifolia*, *Prunus himalaica*, and *P. imanishii* (that the last has yellow flowers seems highly improbable). The Japanese botanists admit that some of the identifications are doubtful, since they were unable to compare their specimens with the types; but on the whole, they appear to be sound, as the numerous references suggest.

If British botanists have lost the opportunity to describe some of the new species which they were the first to discover in the Nepal Himalaya, that is not the fault of the Japanese. The leisurely approach to new collections adopted by British institutions may ensure greater accuracy and longer-lasting results, thereby laying a stable foundation for the next leap. Yet for them accuracy has become a fetish, obscuring the fact that absolute accuracy is elusive. The Japanese approach by an all-out combined effort sustains interest in the expedition itself, and sets a zero from which the experts can start.

The nomenclature is not always up to date, *e.g.* Clerodendr*on*, *Lilium giganteum* (*Cardiocrinum giganteum*); but here again botanists are not misled. The line drawings are consistently good, as one might expect; but the photographs of plants in nature, though most of them are readily recognizable, are hardly up to standard. (Figure 21 is surely not Paraquilegia; nor does the caption fit that species.) The photographs of formations, with a few notable exceptions, have not reproduced well; and it is a further blemish to have placed pairs facing one another, so that too frequently they suggest one, and not two, scenes (*e.g.* XVI and XVII, XVIII and XIX). An interesting comparison is drawn by Sasuke Nakao between the ecology of the Nepal Himalaya and that of the Japanese forests. A clear map of the routes followed completes this very considerable achievement, on which the Fauna and Flora Research Society of Kyoto must be congratulated. F. K-W.

MOSLEMS ON THE MARCH. By F. W. Fernau. *London: Robert Hale*, 1955. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xiii+312+vi *pages; maps.* 16*s*

This is a painstaking piece of bookmaking on a very big subject, so it is scarcely surprising that it is not wholly successful. Mr. Fernau knows some parts of the Islamic world well, for he specialized in that field, as a German journalist; but in 1942–5 he worked in the German Consulate in Istambul which perhaps accounts for the best chapter in this book—that on "The Turks: Anatolian Stability." A similarly detailed knowledge of all the Moslem countries is hardly to be expected; but none between the Maghrib and Pakistan pass undiscussed, though he does not penetrate to Indonesia.

This is not a book for specialists but the general reader will find it interesting and, at times, fascinating. The author sets out to review the inter-continental belt of Moslem lands which stretches across the world's middle; he even suggests that it may increase its size and shape by triumphing in Africa, as "colonialism" loses its power.

The importance of this area today is enormous, not least strategically and economically, and much depends on the Moslem decision about their future purpose, now that imperialism seems to be in retreat. The Persian oil crisis of recent years, its solution, and the parts played therein by Great Britain, the U.S.A. and Soviet Russia

respectively, are discussed in some detail from a viewpoint unfamiliar to the English reader at times, for Mr. Fernau has been a member of the Middle East Institute in Washington since 1947.

The first four chapters fill in the historical background but the second and larger part deals with events and conditions of recent years. Throughout the book is eminently readable; if it was read by the general public as widely as it deserves to be, greater understanding might grow where it has been badly needed and may be again. R. A. R.

FORGOTTEN KINGDOM. By PETER GOULLART. *London: John Murray*, 1955. $8\frac{3}{4} \times 5\frac{3}{4}$ *inches;* xix+218 *pages; sketch-map and illustrations.* 18*s*

This is a delightful account of life in one of the least-known corners of China during the decade immediately preceding the establishment of communist rule. The "forgotten kingdom" is in fact the ancient Nakhi Kingdom of Yunnan, in whose principal town, Likiang, the author, an emigré Russian with a life-long knowledge of China, served for nine years as the representative of the Chinese Industrial Co-operatives. Although on account of its remoteness no Han Chinese candidate could be found who was willing to work in this "mountain-girt no-man's land, lost in a sea of barbarous tribes," the author was completely enthralled by its natural beauty and developed a deep affection for its people. These enthusiasms he succeeds admirably in conveying to the reader and his book is further enriched by a wealth of photographs, some of which are of exceptionally high quality. One of the most interesting sections of the book is that which deals with the early trials and subsequent triumphs of the industrial co-operative movement in an area where even a simple wool spinning-wheel was a nine-days' wonder. But to most readers the greatest interest will probably lie in the absorbing descriptions of the different ethnic groups—Nakhi, Tibetan, Boa, Lolo and Minkia—inhabiting this complex borderland between China and Tibet. The book ends on a tragic note with a brief but disturbing account of the "liberation" of the Likiang valley by the communists, an account which should be pondered by all those who so glibly assert that the new régime has solved the age-old minority problems of China. C. A. F.

ENNIN'S DIARY. Translated from the Chinese by EDWIN O. REISCHAUER. *New York: The Ronald Press*, 1955. $9\frac{1}{2} \times 6\frac{1}{4}$ *inches;* xvi+454 *pages; end-paper maps and plates,* $7.50

ENNIN'S TRAVELS IN T'ANG CHINA. By EDWIN O. REISCHAUER. *New York: The Ronald Press*, 1955. $9\frac{1}{2} \times 6\frac{1}{4}$ *inches;* ix+341 *pages; end-paper maps.* $5.00

In these two volumes Professor Reischauer of Harvard has made an outstanding contribution to the study of T'ang China. The first volume consists of an elaborately annotated translation of the diary kept by Ennin (Jikaku Daishi), a Japanese Buddhist monk who visited China from A.D. 838 to 847 as "a pilgrim in search of the law." As the first written account of life in China by any foreign traveller the diary is an historical source of the greatest importance, though its value to the geographer is not so great as one could wish owing to the author's primary concern with religious matters and subsequently with his own unfortunate experiences during the T'ang persecution of Buddhism (842–846). This is essentially a work for the specialist Oriental historian.

On the other hand in the companion volume, 'Ennin's travels in T'ang China,' Professor Reischauer caters for a wider audience. Using the diary as his principal source, but drawing also on his own rich knowledge of Far Eastern history, Professor Reischauer makes a fascinating reconstruction of the day-to-day life of northern China at the time of Ennin's pilgrimage. This is a most readable and illuminating account and, although not primarily topographical, it contains innumerable interesting side-lights on conditions of travel, the state of roads and canals, and the cost and

quality of food and lodgings. There is also a brief but admirably lucid section assessing the rôle of the tribute-bearing missions in the international relations and the early commerce of the Far East (in Chapter III) but perhaps the most valuable contribution of all is that on the Koreans in China (Chapter VIII) which throws new light on an unfamiliar corner of Asian history. Although the days of their maritime supremacy were already numbered, the Koreans were the leading seamen of the Far East during Ennin's time and from his account it seems clear that the commerce between eastern China, Korea and Japan was mainly in their hands. Professor Reischauer sets this traffic in its world perspective by showing how the Near Eastern merchants stopped short at the Yang-tze delta, beyond which the Koreans took over for the last stage of the trade route from the Indian Ocean to the easternmost corners of the known world. Thus, in far more difficult waters on the eastern fringe of the Eurasian landmass, they performed similar peripheral functions to those of the Mediterranean traders on its western fringes.

The two volumes are handsomely produced and, although there are no illustrations, apart from an idealized twelfth-century portrait of Ennin in the *Diary*, the end-paper sketch-maps (the same in both volumes) are well drawn and form a useful supplement to the text. C. A. F.

CENTRAL ASIAN TRAVEL

ANOTHER ROAD TO SAMARKAND (*Hodder and Stoughton*, 1955, 16*s*) deals with peoples and places which were once comparatively well known to travellers. It is only recently that they have been once again admitted to Russia and Central Asia and therefore Patrick Sergeant's book is of considerable interest. It is light and largely non-political, but gives a good picture of Russians and the peoples of Central Asia at work and play. Mr. Sergeant also visited Ukraine, Siberia and Georgia and it is encouraging to find that in Georgia particularly the people have been able to retain much of their individual character and colour. Communists are no doubt all-powerful in the Russian dominions, but human nature is still strong enough to resist those modern forces which seek to reduce everything to one drab uniformity.

Because of its disturbed political state and independence, Burma is less known to us than it used to be. Miss Ethel Mannin, who was seeking material for a new novel, has given a sympathetic account of her travels from Rangoon to Metgui in the south, and Lashio in the north, in LAND OF THE CRESTED LION (*Jarrold*, 1955, 16*s*). She was treated with great friendliness, but was sometimes exasperated by procrastination and the failure of minor officials to follow the example of their supervisors. Her book gives a fair picture of life in Burma as it is today. She avoids discussion of the difficulties experienced by the Karens and other subject races and appears somewhat biassed in favour of the Burmans. This is perhaps inevitable in view of her contacts and the auspices under which she travelled. Her description of the countryside with all its beauties contrasts with the discomforts of travel and will bring back happy memories to those who have lived in Burma.

The "abominable snowman" has as great a power of attraction as flying saucers and men from Mars. He may be a monkey or a bear or perhaps he really is a link with prehistoric man. Whatever the answer there are many who will follow the investigation with great interest and surely the recent expedition in search of him will not be the last. Mr. Ralph Izzard has set out clearly such evidence as exists and as found by himself and his companions in THE ABOMINABLE SNOWMAN ADVENTURE (*Hodder and Stoughton*, 1955, 15*s*). The Sherpas believe in the *yeti's* existence, as does Mr. Izzard, but scientists will need more than footprints in the snow, droppings and noises in the night before they accept the existence of a new anthropoid creature. Considering the nature of the country and the animal's apparent habits it is almost more likely that success will come by chance rather than as a result of a special expedition. In any case patience and persistence are essentials.

Sherpas have, in fact, been much in the news recently and three further books under review are very good examples of what can be done to bring to the general reader these gay and happy mountain dwellers. They are all concerned, however, with only a small part of Nepal and describe the way of life of only one tribe: Miss Ella Maillart has made a fine collection of photographs (THE LAND OF THE SHERPAS, *Hodder and Stoughton*, 1955, 18*s*); Mr. Stonor, who was a member of the Daily Mail expedition led by Mr. Izzard, also hangs his story upon the exacting search for the "abominable snowman" (THE SHERPA AND THE SNOWMAN. *Hollis and Carter*, 1955, 18*s*); and Mr. Tom Weir describes a happy journey in which mountaineering was the excuse for an enjoyable sojourn among the Sherpas (EAST OF KATMANDU. *Oliver and Boyd*, 1955, 16*s*). Miss Maillart's book consists of a short introductory description of her journey and the people that she met, followed by pictures of the high valleys and places of pilgrimage. The photographs are mainly her own and each has a descriptive note. The whole gives a fine idea of life in Nepal with all its beauties, both natural and architectural. J. E. F. G.

AFRICA

THE RED SEA MOUNTAINS OF EGYPT. By L. A. TREGENZA. *London: Oxford University Press*, 1955. 247 *pages; map and illustrations.* 21*s*

The title is a bit of a misnomer for the author only deals with a small part of the Red Sea Hills round the famous Roman quarries of the Mons Porphyrites and Mons Claudianus, visited on a hot holiday alone with Arab companions during the summer of 1949. Mt. Tregenza is a keen observer of natural history and his observations are supplemented by those of his Arab companions. It is most interesting to learn that, though the White Storks can cross the Gulf of Suez direct on migration the multitudes of eagles and vultures—Mt. Tregenza has seen a thousand of these together—have to make their way round the head of the Gulf of Suez. The author is an archaeologist, too, and spent ten days at Abu Sha'r el-Qibli, generally identified with the classic Myos Hormos. An ostrakon he picked up on the road to that place strengthens the identification. G. M.

SOUTHERN AFRICA. By JOHN H. WELLINGTON. *Cambridge: University Press*, 1955. Vol. 1, 528 *pages;* Vol. 2, 283 *pages;* 9×6 *inches; maps and plates.* Vol. 1, 70*s*, Vol. 2, 35*s*

Professor Wellington's long-awaited definitive geography of southern Africa is at last completed, and perhaps the best summary impression that can be given is that it was worth waiting for. In scope and content it is a *tour de force*. The results of more than thirty years of first-hand field research over an astonishingly large proportion of the sub-continent have been combined with the mastery of a voluminous literature to produce that rare phenomenon, a pioneer effort on the grand scale that achieves immediate maturity and authority. That is not to say that the problems have all been solved, and Wellington himself is scrupulous in pointing out where more data are required, where conclusions are tentative and where little more than intelligent guesses can be given. As time goes on and knowledge accumulates, some ragged edges will be trimmed, some gaps filled in and even, perhaps, some judgments reversed, but the patent fact that all such revision can be accommodated within the present plan of the work bears witness to the thoroughness of the author's appreciation of the essential character of his area.

The scope of the work, be it noted, is southern Africa, not the Union of South Africa. The northern boundary is one that physically "stands out more clearly and definitely than any other, namely, the watershed between the Congo and its smaller western neighbour, the Cuanza, on the one hand, and the Zambesi with a similar neighbour, the Cunene, on the other hand." The Rhodesias and Nyasaland are therefore included, as is the southern half of Angola. East of Lake Nyasa the boundary

is so chosen as to include the whole of Mozambique and the southern edge of Tanganyika as well. Inevitably, however, the Union gets the lion's share of attention, not only because of its dominance in population and in economic development, but also because of the vastly greater amount of research that has been done and of information that is available there. In particular, the treatment in Vol 2 of the people, their numbers, distribution, racial divisions and stresses, is virtually confined to the Union.

Vol. 1 (Physical) is almost double the size of Vol. 2 (Economic and Human), and this no doubt reflects some bias of interest on the part of the author, but certainly reflects no loss of competence in Vol. 2. The two volumes are alike in having three parts. In Vol. 1, Part 1 deals with the physical geography in the narrower sense and includes a very useful scheme of physiographic regions. Here for the first time is a comprehensive consideration of the geomorphological history and character of the area. Part 2 is concerned with climate, vegetation and soils. The climate is related to current views of the origin, nature and movement of the relevant air masses, the vegetation to the climate on the one hand and to the pastoral industries on the other, the soils to parent material, climate, vegetation and utilization. Part 3, a thorough and detailed examination of the hydrography, is a recognition of the overwhelming importance of water supply, especially in the Union, where, for instance, the industrial expansion of the Rand may already be nearing an end with the approaching complete utilization of all available water supplies. In Vol. 2, Part 1 (Land utilization) considers crops and livestock, with special attention to the difficulties and to the methods being adopted to overcome them. Part 2 (Mineral and other industries) lays special stress on gold, coal and the iron and steel industry, but not to the neglect of other minerals and industries. Here, too, the problem of water supply, for domestic use, hydro-electric power and the demands of great and growing industries, is once more emphasized. In Part 3 the treatment of the racial problem is developed against a background of the population history. In its sympathy for the non-white peoples, combined with realistic appreciation of how much they have still to learn, Wellington manages to avoid extremism on either side and to achieve a standard of objective judgment and tempered optimism rarely to be found.

It will be noted that the treatment in Vol. 2 is wholly by topics, and one may be permitted a measure of regret that no regional scheme, comparable to the physiographic regions in Vol. 1, was attempted. Even if that is admitted as a just criticism, however, it is a very minor one. The work as it stands, the most massive achievement in English by any geographer for at least a generation, bears the stamp of high quality throughout its great length, and will certainly remain the standard and authoritative geography of southern Africa for longer than one can foresee. R. O. B.

NATAL REGIONAL SURVEY. Volume III: THE DISTRIBUTION OF POPULATION IN NATAL. By T. J. D. FAIR. *Oxford University Press*, 1955. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches; 107 pages; 37 maps and diagrams.* 30*s*

The Natal Regional Survey, undertaken by the University of Natal for the Social and Economic Planning Council of South Africa, is helping to build up a clear and comprehensive picture of the socio-economic pattern of this small, but densely populated, coastal province of the Union of South Africa. Another volume of this Regional Survey has now appeared, a valuable addition to this admirable series. This is a concise and scholarly work by Dr. T. J. D. Fair of the Natural Resources Development Council, on the distribution of population in Natal. There is a brief introductory chapter outlining the natural landscape of Natal. The next chapter outlines in more detail the evolution of the pattern of population distribution influenced by a wide variety of physical and human factors. Natal has a diverse physical environment ranging from sub-tropical coastal lowlands to the Great Escarpment nearly 11,000 feet in altitude in places. But the physical background has only an indirect influence, human factors being more important in their effect on population distribution in Natal. The basic pattern had already been laid by the end of the nineteenth century

with urban nuclei at Durban and Pietermaritzburg, the main agricultural belts, coal mining in northern Natal, the native reserves, the concentration of Indians in the coastal region and the road and rail route to the Witwatersrand.

There is a multi-racial population in Natal with four different racial groups; nearly three-quarters of the total population of about 2,400,000 being natives. Each of these groups tends to live in clearly defined areas; 84 per cent. of Natal's Indians living in the narrow coastal strip south of the Tugela river, while the native reserves, occupying about one-third of Natal, are situated in the more rugged parts of the province. There is a great contrast between the so-called European areas, forming about two-thirds of Natal, with a diversity of economy, well developed communications and towns and the native subsistence areas with their lack of communications and towns, and little economic development. Economic forces are tending to cause greater integration, however, and a significant factor has been the great increase in urbanization and the rise of secondary industries, particularly in Durban-Pinetown and Pietermaritzburg, during the last thirty years.

The agricultural, mining, industrial and urban populations and the native areas are then described, and the book concludes with a useful summary in the form of a regional synthesis and conclusion. There is a wide range of population distribution maps, most of which are of a high standard. Some have, however, suffered inevitably from reduction and are insufficiently clear or have too much detail. The book would benefit by the inclusion of a few photographs and an index. The geographical background is apparent throughout. N. C. P.

TOWN PLANNING IN UGANDA. By HENRY KENDALL. *London: Crown Agents for Overseas Governments and Administrations*, 1955. 12×10 *inches; 91 pages; maps and plans.* 10*s*

Uganda is experiencing a period of population growth coupled with rapid economic expansion. While the land still supports the great majority of the African inhabitants, the recent policy of industrialization and the prosperity created by the success of coffee and cotton as cash crops have led to a considerable increase in the town populations, particularly in Kampala and Jinja. The faces of these towns are changing almost daily. Indeed, as long ago as 1950, the year before the publication of the 1951 Outline Scheme for Kampala, over £5,000,000 worth of building was being undertaken in that town. With the current mining developments in eastern and western Uganda, Tororo and Fort Portal are both likely to increase rapidly in size and prosperity. Town planning for a multi-racial community—European, Asian and African—in such a comparatively undeveloped but fast advancing country is a subject full of interest to the geographer, the economist and the sociologist. It is somewhat disappointing to read in Mr. Kendall's preface to 'Town Planning in Uganda' that as a large number of publications have appeared during the post-war period dealing with many aspects of development in Uganda, he proposes to avoid repetition and to concentrate on the physical development of towns to the exclusion of other matter. Mr. Kendall describes his book as a compilation of past efforts made in Uganda to control and direct developments in the main urban centres. While he achieves his purpose clearly and concisely, the very cursory treatment of such matters as geological and meteorological conditions, present population distribution, land and land tenure, and the siting of industries leaves the description of past plans in a vacuum to those without a detailed knowledge of Uganda.

The greatest emphasis in the book is naturally on town planning in Kampala and Jinja. The Kampala planning schemes of 1919, 1930 and 1951 are outlined, and the 1951 scheme is set out in full in an appendix. The account of planning in Jinja is rather more satisfying, although less space is devoted to it, probably because it is accompanied by a larger amount of background information including a series of twelve maps of Busoga District, illustrating in diagrammatic form the regional background to the planning of Jinja. Lesser towns such as Entebbe, Masaka, Mubende,

Mbale, Tororo, Fort Portal, Kabale and Gulu are dealt with sketchily. It is not very rewarding to learn of the planning scheme for Masaka that it "follows the usual pattern of development in the minor towns" and "makes provision for the extension and development of trading and commercial activities of all kinds."

The chief weakness of the book lies in its failure to show clearly the problems facing the planner and the goals towards which he is working. One can hardly blame Mr. Kendall for not achieving what he did not in fact set out to do. But the reader is left with many questions unanswered regarding the plans for the future of Uganda's towns, both as working and as living places for Africans, Asians and Europeans. The book is profusely illustrated by photographs and drawings, and by maps of the various planning schemes. J. M. R.

LATIN AMERICA

THIS NEW WORLD: The Civilization of Latin America. By WILLIAM LYTLE SCHURZ. *London: George Allen and Unwin Ltd.*, 1956. 9×6 *inches;* xii+429 *pages; maps and sketches.* 25*s*

ARGENTINA. By GEORGE PENDLE. *London and New York: Royal Institute of International Affairs*, 1955. 8×5½ *inches;* x+159 *pages; maps.* 12*s* 6*d*

BRASIL: La Gran Potencia del Siglo XXI. By ANTONIO MEIJIDE PARDO. *Santiago de Compostela: Porto y Cia.*, 1955. 8¼×6¼ *inches;* xiv+410 *pages; maps and diagrams.* 90 *pesetas*

LE BRÉSIL. By MAURICE LE LANNOU. *Paris: Librairie Armand Colin*, 1955. 6½×4½ *inches;* 224 *pages; maps.* 300 *francs*

The publication of the British edition of William Schurz's treatise on Latin American civilization is an event which all students of that continent will welcome enthusiastically. For those others unacquainted with its history and geography, no book offers a more fascinating introduction to the basic components of its social, economic and political life. It is an absorbing treasury of information brought together by one of the foremost scholars of Latin America today, and his wide experience there has produced a volume not only vibrating with a sympathetic and unpatronizing understanding of the Latin Americans, but critically evaluating the difficulties yet to be surmounted.

After an introductory chapter on the environment, viewed principally from the angle of its impact on the Iberian colonist, the author examines the various human elements —the Indian, the Spaniard, the Negro and the "Foreigner"—which have helped to mould the character and culture of Latin America today. The second half of the book contains a detailed consideration of the three basic institutional forms, the family, the city and the Roman Catholic Church, in which the continent's civilization has found its most typical expression.

The lucid style and arrangement, the relevant historical quotations and the excellent chapter-end notes and bibliographical references combine to produce a truly scholarly work. It is all the greater pity that the maps contain locational errors in the siting of such towns as Ciudad Bolivar, Manaus, Puno and Punta Arenas.

'Argentina,' the eighth of the Chatham House studies on the Latin America republics, completes Mr. Pendle's trilogy on the River Plate republics, and like his 'Uruguay (1952) and 'Paraguay' (1954), it well reflects his broad knowledge and understanding of this great region. The book is primarily a social, political and historical analysis to enable the reader "to understand why the Argentine people are what they are and why they behave as they do," and the story is carried down to the overthrow of the Peronista régime, one-third of the study being devoted to the last dozen years. The author is well aware that his interpretation of such recent history will not meet with unqualified approval, but his assessment is probably the least prejudiced account available. Statistics are only quoted to throw light on the country's historical evolution, and the geographer will be disappointed at the absence of any

coherent study of he present-day Argentine economy. A classified bibliography is a most useful feature of the book.

Very different in its approach is Professor Mejide's analysis of the present economic geography of Brazil and the physical, demographic and economic basis which underlies this "great power of the twenty-first century." Supported by 35 maps and 150 statistical tables it presents a comprehensive, almost encyclopaedic account of the natural background, the peopling, the economic evolution, the natural resources and the industrial growth of this vast sub-continent. For the most part a factual statement of the economic structure from a geographical approach, some chapters portray the potential power and absorptive capacity of the empty lands and industrial fabric of this fast-growing nation of sixty million people.

Less optimistic in its outlook is Professor Le Lannou's splendid little survey of this same great continental expanse. Illustrated by a useful set of maps it contains a broad physical, historical and economic summary, an excellent regional treatment and a careful assessment of present social and economic problems. For both the geographer and the non-geographer there is no better introduction to the diversity of the Brazilian scene. G. J. B.

AUSTRALASIA AND THE PACIFIC

THE BOTANY OF COOK'S VOYAGES. By E. D. MERRILL. Chronica Botanica, edited by Frans Verdoorn, Vol. 14, no. 5/6. *Waltham, Mass.: Chronica Botanica,* 1954. *London: William Dawson,* 1954. 10½×7 *inches;* iv+161–485 *pages; illustrations.* $4.75

It is fitting that at the same time as the publication by the Hakluyt Society of the 'Journal of Captain James Cook' this account of the fate and significance of the collections of plants that were made on Cook's voyages should also have appeared. The author is particularly well qualified to discuss their importance in the study of the vegetation of the Pacific region because there has probably been no other botanist with as wide and as close a knowledge of the western islands. Professionally a systematist, he has had to establish the validity of many of the scientific names of Pacific plants and this led him to the manuscripts of Cook's collectors, Banks, Solander and the Forsters, and the artist, Parkinson. The inter-relationships of these naturalists were complicated and sometimes strained, and Dr. Merrill reveals in passing a tantalisingly incomplete sketch of this chapter of botanical history. The consequences of their inability to cooperate are reflected in much of the confusion in nomenclature that still persists in Southern floras.

The Tahiti collections, which figure prominently in those brought back by Cook's expedition, are of some importance in the arguments for and against the view that the Polynesian islands were colonized from the American continent. As Dr. Merrill points out, there is good evidence that Cook's collectors were not likely to fail to collect a plant because it was cultivated or evidently adventitious. The plants brought back by them are the first genuine indication we have of the food plants of the Polynesians and their agricultural weeds. There is not a preponderance of American species, which we might expect if the inhabitants did in fact come from that Continent. Unfortunately, argument on this point has become rather acrimonious amongst American plant geographers, and this otherwise excellent book is marred in several places by a lack of objectivity. P. B.

VOYAGE TO THE AMOROUS ISLANDS. The Discovery of Tahiti. By NEWTON A. ROWE. *London: André Deutsch,* 1955. 8½×5½ *inches;* 256 *pages; plates.* 21*s*

An account of the second voyage of H.M.S. *Dolphin* around the world was published by Hawkesworth in 1773, and the journal of her master, Robertson, was published by the Hakluyt Society in 1948 (see *Geogr. J.* **114** (1949) 213–14). Mr. Rowe's book is still another account of the voyage, compiled from all the relevant documents available

in the Public Record Office and to which Hawkesworth presumably had access. Mr. Rowe claims as qualifications for writing the book that he has sailed in the Pacific, has visited Tahiti, and has lived amongst Polynesians. His text indicates that those whom he knows best the Samoans. His enthusiasm for his subject is beyond question, but his writing is mediocre, and his scholarship not quite equal to the task he undertook. He presents the Tahiti of 1766 in the light of the Tahiti he has seen, which is reasonable; but he refers, for instance, to the island of Moorea, a name not heard by the men of the *Dolphin*, for it was called Aimeo in 1766. He maintains that what the early European observers from the sea thought were grassy lawns on the flanks of Tahiti were groves of bamboo. I can find no mention of bamboo by Cook or Banks in 1769; and Forster, who went on botanical excursions into the interior of Tahiti on Cook's second voyage seems to have seen no bamboo groves, but he did see open areas of green turf. There is no doubt that bamboo flourishes in Tahiti now, but it is doubtful that it was the important material Mr. Rowe supposes it to have been in 1766. He also offers ready explanations of Polynesian belief, where a scholar would say with Dr. Beaglehole that "the matter is so complicated that 'one hardly dare touch upon it' in a footnote." And it is hard to believe that Carrington, when editing Robertson's journal, would have missed a second journal by Robertson, said by Mr. Rowe to have been bound up with Wallis's journal, particularly as both he and Carrington give the same reference for the latter, P.R.O., Ad. 55/35. Mr. Rowe should have been much more specific in his description of this second journal. It is unfortunate for him that his book should appear at the same time as Dr. Beaglehole's edition of the journal of Cook's first voyage (Hakluyt Society, 1955), in which Tahitian affairs during the period of exploration are so lucidly interpreted; for, what Mr. Rowe and his publishers lead us to expect, is enlightenment on Tahitian political behaviour towards the *Dolphin*. We do not get the kind we need. M. A.

PHYSICAL AND HUMAN GEOGRAPHY

REALMS OF WATER. By P. H. KUENEN. *London: Cleaver-Hume Press*, 1955. $9\frac{1}{2} \times 6$ *inches; 327 pages; illustrations and diagrams.* 35*s*

In view of Professor Kuenen's great reputation as a geologist something better might have been expected of the book under review. It is intended as a treatment of the water-cycle, and is written for the non-expert, *e.g.* the student of natural sciences. The theme itself and the method of treatment offer great possibilities of stimulating interest and imagination: water in its various forms is of first importance in meteorology, geography and geology, not to mention pedology and the biological sciences, and the author, with this principle in mind, deals in turn with water in the oceans, water in the atmosphere, water in the solid state, water in the ground, water on the surface, and the water balance. The result, however, is less a synthesis than a discourse.

Some authorities consider translation an impossible task. In this book the more obvious pitfalls of translation have, for the most part, been avoided, although a certain stiffness and uniformity of style are evident. Nevertheless, such expressions ought not to occur as "dip" (for "gradient," p. 27), "ambient temperature" (p. 97), "gelated" (p. 137), "tarn" (for "doline-lake," p. 205), "laminary" (for "laminar," p. 260), the equation of valley meanders with incised meanders (p. 267), and "sliding meanders" (for "ingrown meanders," pp. 269, 271). Paragraphing and, in some places, punctuation could be improved. Other errors include the spellings "stratosfere" and "troposfere" in Figure 48.

Much of the matter is likely to be familiar to many readers. This statement applies not only to principles but also to numbers of the abundant examples, and indeed to the illustrations. There is however much concerning the East Indies that is likely to prove both new and useful. Certain explanations, *e.g.* those of supersaturation and of avalanches, are notably concise and clear, and comparisons are frequently made that are both apt and striking, *e.g.* between the speed of glacier-movement and the

speeds of the hands of a watch. The text would be improved by reference to recent (and, in some places, not so recent) research. For example, on p. 41 an erroneous explanation of tidal bores is given; much more is known than the author allows about the formation of corries (p. 157), the depth of Greenland ice (p. 175), the development of meanders (pp. 261–3), the relation between stream-gradient and speed of flow (p. 272) and of that between deposition and stage of flood. Under these last two heads the statements made are simply incorrect. Some of the numerous line-drawings suffer from heaviness. There is an excellent index. G. H. D.

GEOLOGY AND OURSELVES. By F. H. EDMUNDS. *London: Hutchinson's Scientific and Technical Publications*, 1955. 9×6 *inches;* 256 *pages; maps, illustrations, diagrams.* 21*s*

As more and more of the surface of the earth becomes subject to "planning," and as pressure on the land leads to buildings being erected on any site that is superficially suitable, so it becomes ever more and more imperative that those responsible for this development should have a sound knowledge of geology. Mr. Edmunds, from over thirty years' experience on the Geological Survey of Great Britain, has provided a book that will be of value both to engineers and also to all those non-scientists who, as every geologist can testify, are full of interest and enquiry when they see him at work. In his dual aim, Mr. Edmunds has succeeded admirably. After an excellent summary of the history and main branches of geology, and an outline of the stratigraphy of Britain, the reader is introduced to the nature and methods of geological surveys and maps, geophysics and geochemistry, borings, water supply, building materials, civil and structural engineering, the winning of coal, ores, oil and gas, and the relation of geology to agriculture and other everyday matters. Finally the author describes the ways in which the amateur can make contact with his fellows, pursue his own interests, and add to the sum of geological knowledge.

The book, which is up-to-date in its information, is full of solid matter, clearly expounded. The photographs and text-figures are good, but it is a pity that there are no palaeogeographical maps to illustrate the geological history of Britain. Among the few minor errors is the statement that Reskijeage cliffs, shown in Plate XIIB, are near Newlyn; they are in fact on the north coast of Cornwall near Camborne. Elsewhere, the pillow lavas of Tintagel are located in North Devon, and a statement on page 134 implies that some towns in Britain draw water from a reservoir 200 or 300 miles away. The system of subheadings and cross-references is thorough, but the index is wholly inadequate and it is to be hoped that this will be remedied in a future edition, since the book is one which should be widely read and owned. M. A. A.

ILLUSTRATED ICE GLOSSARY. By TERENCE ARMSTRONG and BRIAN ROBERTS. *Cambridge: Scott Polar Research Institute*, 1956. *Polar Record*, Vol. 8, No. 52. iv+12 *pages;* 40 *plates.* 5*s* (*separate*)

This timely publication by the Scott Polar Research Institute will be welcomed by sailors, airmen and scientists who travel in the Polar Regions. The work is based on discussions with various people extending over fifteen years. The authors' combined wide knowledge and experience of the Polar Regions highly qualify them to compile the results of these discussions. Dr. Roberts has long been an authority on ice terminology, especially in the Antarctic, and Dr. Armstrong has made special studies of sea ice in Canadian and Russian arctic waters. The glossary is a development of a 1953 Admiralty publication, "with such modifications as seem to be required for international agreement." The Department of National Defence of Canada is publishing a similar glossary for use in Canadian waters.

A total of sixty-eight terms, each with its admirably concise definition, have been listed as a minimum requirement for the aid of ice pilots and those who report ice conditions. The glossary covers all forms of sea ice, features associated with sea ice, and terms describing the action of sea ice. Thirteen of the terms are applicable only

to glacier ice, especially of coastal regions, or to calved portions of glacier ice. *Ice island*, describing rare tabular bergs from one or two arctic ice shelves, is the only term applicable in only one polar region. A classified summary of the terms is appended. Mariners and others, unused to the metric system, may be heretical enough to wish for dimensions in inches, feet, and miles to be given in brackets.

The recommendation that *bay ice* rising more than 2 metres above sea level (*i.e.* more than, say, 10 metres thick), should be called *ice shelf* provides a good working definition. However, under the definition of *glacier*, it is implied that all ice shelves are "continuously spreading," although this can hardly be true of certain thin ice shelves. Perhaps the term *icefoot* could be amplified a little. While many icefoots are potential landing places, some are fringed by heavy grounded sea ice.

The forty quarter-plate photographs, featuring nearly all the terms described, amply justify themselves. Rather more than half appear to have been taken on antarctic expeditions.

Although the authors emphasize that the glossary is provisional, it embodies a remarkably clear and adequate—but not redundant—terminology. G. H-S.

DAS EISZEITALTER: Grundlinien einer Geologie des Quartärs. By PAUL WOLDSTEDT. Vol. 1. *Stuttgart: Ferdinand Enke Verlag*, 1954. 9½×6 *inches;* viii+378 *pages; maps and illustrations.* 41 *DM.*

In a preface the author states that this is to be the first of two volumes describing the general phenomena of the last Ice Age and that a second volume is destined to deal with the Quarternary geology of the whole Earth, region by region. He adds that as regional Quaternary research embraces more than just former glaciations this of itself is a big task. This would seem to apply too to the volume under review, itself no small task and admirably accomplished by one of the great authorities on the subject.

The first four chapters deal with the present-day glacierization down to details of the change of snow into ice, the structure of the ice crystal and the flow of glaciers (with not all of which latter the reviewer is able to agree). A chapter is devoted, excellently, to the erosional features caused by glaciers. We are still uncertain about the exact nature of the mechanism of glacial erosion and one can hope that more observations will soon be carried out at the points of contact between ice and rock, admittedly a very difficult operation.

Further chapters describe moraines and other evidence left by former glaciers and ice sheets, and the "periglacial" phenomena beyond the domain of actual ice—"drift," sands, loess and the like. Interglacial and "interstadial" conditions, the latter denoted by a flora and fauna typical of cold-temperate fluctuations between two cold periods, are dealt with in much detail. Mention is made of the recession of the Ice Age and of the attempts which have been made to estimate its span. Penck is cited as giving its duration as of the order of six thousand centuries.

Succeeding chapters deal with the Ice Age flora and fauna as a whole, the advent of Man and his various advancing civilizations.

A chapter is devoted to the immensely complex interplay of eustatic changes of sea level due to the exchange of material between sea water and land ice, and the attendant isostatic movement of the Earth's crust as the overlying weight shifts from continent to ocean. The general view is that the melting of the whole of the world's ice would raise the level of the seas by from 30 to 60 metres. Although the author qualifies this estimate with his belief that it does not fully take into account the resulting isostatic sinking of the sea bed, so that the figures may well be less, the thought of what the map of the world would even then look like is a pretty grim one.

The many climatic changes of the period are put forward in much detail, as also the various theories, terrestial and extra-terrestial, which have been proposed to account for them.

The book is uncommonly pleasing to handle for a work of this type. The paper and

the printing are of just the right quality, and the reference list and illustrations are adequate. The index is good and, as a useful additional aid to the search for any special point, the chief section headings of each chapter are listed on the contents page and are printed in heavy type in the body of the book. Publishers of other scientific works would do well to copy. G. A. S.

DIE EISVERHÄLTNISSE DER KÜSTENGEWÄSSER VON MECKLENBURG–VORPOMMERN. By JOACHIM BLUTHGEN. (Forschung zur deutschen Landeskunde Bd. 85.) *Remagen: Bundesanstalt für Landeskunde*, 1954. 9×6½ *inches; 142 pages text; 28 photographs; 33 tables; 55 maps; 36 figures.* 14.50 *DM.*

This work deals with the ice conditions of the coastal waters of Mecklenburg, and includes the seas off the Bay of Lübeck and the Trave in the west, to Swinemünde and the Stettiner Haff in the east. The data have been compiled from the observations of the former German Naval Observatory (Deutsche Seewarte) and, after the last war, the Ice Service of the Observatorium Greifswald in Mecklenburg. It connects with work done in 1936 and 1938 further east by the author, for many years known as one of the first authorities on sea ice and particularly of the ice conditions in the Baltic.

Chapters are devoted to the climatological and oceanographical features of the area—wind, temperature, drift—combined with the topography of the coast. The depths of the sea are very small in many places near the coast, leading to heavy ice development.

The synoptic conditions of the various individual phases of ice formation are made very clear in excellent weather maps. The influence of snow falling on the sea is dealt with in considerable detail both in regard to its coagulating to form a covering of ice and as an insulating agent to influence further ice growth below.

Ice types are listed in some detail and defined. In some cases the Russian equivalents of the German are given in German characters. An interesting section of this chapter shows the differences between ice development around the North Pole and in the confined areas of the Baltic coasts. Other chapters deal with the mean sea ice cover of the whole area, with the areas of heavy ice (excellently demonstrated with a map, Karte 55), and with the economic bearing of the ice conditions on the movements of shipping and on fishing operations. Sassnitz and Warnemünde suffer least in respect of the hold-up of shipping.

The chapters describing duration and condition of the sea ice cover in a large number of coastal stations and the numbers of "ice-days" together with probability of ice forming (*Eiswahrscheinlichkeit*) are claimed by the author as being the most important part of the work. This they would certainly be from the local point of view, but the reviewer believes that much of the whole work is likely to be of great value to a wide circle.

The work contains a large number of plates and diagrams although reference to these is not always quite clear. The maps, synoptic and geographical, are excellent. The photographs of ice types are only fair. There is a large bibliography, but unfortunately no index. G. A. S.

OUR ASTONISHING ATMOSPHERE. By J. GORDON COOK. (Science for Everyman.) *London: George G. Harrap*, 1955. 8×5 *inches; 200 pages; illustrations.* 10*s* 6*d*

This is a summary of information now available about the atmosphere, especially in relation to human life and achievement, and as such the volume is of considerable interest and educational value. It deals more with atmospheric physics and chemistry than with meteorology, covering such widely different aspects as high-altitude flight, sound and ultra-sonic waves, wind power, cloud-seeding for rain-making, cosmic rays, aurora, smoke, germs, dust, ozone and the various gases of the atmosphere including the wide industrial usages of oxygen and nitrogen. There are also some specifically

meteorological chapters with a fairly good account of weather types, forecasting and upper air conditions including the jet stream.

It is a pity, however, that the otherwise excellent chapter entitled "Turmoil in the Thundercloud" explaining the modern cellular theory of these clouds should be marred by the following climatological error: "Thunderstorm activity reaches its height in Britain during May and again in September, with the Manchester area, the Severn Valley and Lincolnshire as the storm centres." All this, of course, might hold in any particular year, but the average over a number of years indicates very distinctly that the summer thunderstorm season in Britain reaches its peak in July, with June and August close behind. L. C. W. B.

THE SIZE AND NATURE OF THE POSTER AUDIENCE. *Survey by Mills and Rockleys, London*, 1955. $7\frac{1}{2} \times 9\frac{1}{2}$ *inches; 69 pages; diagrams*

Recent years have seen various practical applications of the results of geographical research work, some of them quite unexpected. This little book is concerned with one very highly specialized way of looking at towns, to determine the facts, figures and formulae necessary to the planning of modern poster advertising campaigns. It describes the methods and analyses the statistical results of sampling the population and asking the persons comprising the samples which locations they have passed and how often. The vocabulary employed is so specialized as to necessitate a special glossary. Geographers will be interested to see the emphatic recognition of the importance of the study of urban hinterlands, but the volume is essentially addressed to advertisers who desire their poster displays to be planned with maximum efficiency. E. C. W.

IRRIGATION CIVILIZATIONS: A COMPARATIVE STUDY. Social Science Monographs I. *Social Science Section, Department of Cultural Affairs, Pan American Union, Washington, D.C.*, 1955. $10 \times 7\frac{1}{2}$ *inches; 78 pages. 50 c.*

This monograph tests the hypothesis of multilinear evolution by examining the development of irrigation and its effects on cultural development in China, America, Mesopotamia and Peru. The geographer will find there some information for his studies of these areas, but the tendency to force the cultural sequence into a set pattern on the basis of social evolution limits the scope of the work.

Such limitations are natural in a specialist methodological study, nevertheless a comparison of areas purely on the basis of "cross-cultural regularities" omits many environmental features which might be very significant to the development of the societies concerned. It is apparent that geographers may learn much from this detailed study of cultural patterns, but there is also scope for the historical geographer to contribute something to redress the balance which is felt to be lacking in this more limited approach, by attempting a regional description of these areas at different periods. G. E. G.

STUDIES IN SOCIAL HISTORY. A tribute to G. M. Trevelyan. *London: Longmans*, 1955. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* xv+287 *pages; plates. 21s*

This *Festschrift* is selective; eight of the many who owe intellectual allegiance to the Grand Old Man have been chosen by Dr. Plumb to avoid a "massive monument of unreadability," but some will feel that the editor has found it easier to reduce mass than to achieve thorough readability. This note is also selective, for only two of the essays are sufficiently concerned with physical environment to be of geographical interest. Professor Habakkuk contributes a study of the building of a large country house at Burley-on-the-Hill by the second Earl of Nottingham between 1694 and 1702. The raw material of the project was an estate of the deceased and debt-ridden Duke of Buckingham. The old house had been burned down in the Civil War and only the stables stood in the way of a new venture in the newest fashion; the stone came from the Clipsham quarries and the bricks were made on the spot from the Rutland

clay. The park was extended to 1360 acres, sacrificing £600 a year in farm rents for the sake of the ornament and prestige. The essay shows a peer touring vacant properties, hovering between a house in Yorkshire and one in the Midlands, and has valuable sections on the ambitions which created this form of display and on the sources of the funds which could gratify the ambition.

Dr. Hoskins' important essay on Elizabethan Leicester deals less with the social life of this small Midland market town than with the physical setting within which the townsman lived and worked. He shows a town without any one single industrial prop (although inclined to tanning); a town busy taking in its own and the countryside's washing; a town of wooden houses; a town with open spaces and gardens in an old core of settlement bounded by the medieval (and Roman) walls, yet flanked on three sides by working-class extra-mural suburbs; a town smaller in the sixteenth century than in the early fourteenth. The sleight of hand in bringing together original evidence and making it not only academically significant but highly readable is a pleasure in itself. There is a reproduction of Mr. D. Charman's map of Leicester in 1525, locally published in 1951, but one may regret that a new map was not commissioned. The topographical changes were few between 1525 and 1603, it is true, but it would have helped to have all the houses and streets mentioned in the essay specifically located. M. W. B.

TRAVEL AND BIOGRAPHY

Variety of scene is the keynote of Stanton Hope's ONE ONLY LIVES TWICE (*Hale*, 1955, 18*s*), a variety expressed on the jacket by a patchwork of photographs depicting the author on an Australian coral reef, a team of timber-hauling elephants in Ceylon, a Japanese mother and child, and a parade of bathing beauties on Bondi beach. In two phases of travel, Stanton Hope has covered most of the globe, and has written a lively book comparing the adventures of his youth with what could hardly, in one so active and tolerant, be called his old age. The two "lives" he claims are the seven years when, towards the end of last century, he went to seek his fortune in British Columbia, and thence to the United States, Alaska, Japan, China and Australia; and the less adventurous period on writing and lecture tours in the years since the Second World War. Variety is just what was missing in the nightmare voyage of HALF-SAFE (*André Deutsch*, 1955, 16*s*), the amphibious jeep which Ben and Elinore Carlin propelled across the Atlantic, in thirty-two days from Halifax, Nova Scotia, to Flores in the Azores. They went on to land on the African mainland at Cap Juby, and from then until they reached London the jeep became a land animal—with the important exception of the Straits of Gibraltar and the English Channel. The achievement was extraordinary and is described with zest; for those who understand such things, the mechanical details will be of much interest. The "crazy Carlins" paid their way by exhibiting the jeep at ports of call and by writing for the press. OVERLANDING WITH ANNABEL (*Angus and Robertson*, 1955, 15*s*) is also the story of a courageous and original young couple, whose means of transport had a personality of its own, but it is more comfortable reading than 'Half-safe.' Stuart and Jan Gore are professional photographers whose arduous, but rewarding, way of life it is to tour Australia with a cinema projector, paying their way by film shows in places where there is little or no commercial entertainment. The Gore programme is entitled "See Australia first" and this book describes a journey in "Annabel," the ancient Chrysler, through the remote areas of north-western Australia, showing pictures taken on earlier travels and taking new pictures to add to the programme. This is but a bare account of a really charming book, full of interesting information and vivid descriptions, and pervaded by the sympathetic personalities of the author and his wife.

The Tuareg, veiled men of the Sahara, exercise a perennial fascination on the travelling European, and the latest book about them is by Peter Fuchs, a young Austrian ethnologist who recently spent six months in the Hoggar mountains with

two companions, Edith Fischer and Andreas Kronenberg THE LAND OF THE VEILED MEN (*Weidenfeld and Nicholson*, 1955, 18*s*). Although the author is a trained observer of people and their ways, and although he and his friends spared no trouble and dodged no risk during a long stay in the Tuareg tents, he fails somehow to convey to the reader any sense of strangeness or distinctive quality in this remote desert tribe. The publisher's "blurb" promises a "colourful narrative" of a "charming and sympathetic people" and one is especially eager to learn about the "Ahals, or famous Tuareg love feasts"; these, however, appear in Peter Fuchs' somewhat naïve account to be little more than a kind of parish tea party or "meeting place for courting couples," where care is taken to "see that everyone behaves themselves." The translation by Bice Fawcett is fluent enough, and the photographs good, but there is no map. It is no strange land, no unfamiliar culture, of which Bernard Llewellyn writes FROM THE BACK STREETS OF BENGAL (*Allen and Unwin*, 1955, 18*s*), but the well-known story of the splendours and miseries of the Indian sub-continent. Mr. Llewellyn's account is both more and less valuable than many that have gone before: more, in that he is a tolerant and compassionate man who has no axe to grind, who can observe and write acutely, and has a most pleasing humour; less, in that he has no historical sense and his judgments are so intensely personal that similar scenes appear to call forth quite dissimilar reactions, according to the state of Mr. Llewellyn's health, the degree of sympathy with his companions, and the weather. The author worked for nine months in the Quaker centre at Dacca and was much depressed by the squalor of his surroundings and what he felt to be the dead hand of Islam on East Pakistan. He finds the Hindu more congenial than the Muslim and was inspired in later travels both by the simple life in Ghandi's ashram at Sevagram and (perhaps inconsistently) by the various schemes for material betterment which the Indian government is pressing forward in different parts of the country. His last port of call was the hospital built and run entirely by a remarkable couple, Laurie and Kuni Baker, at Pithoragarh on the borders of Nepal. D. M.

Most eminently readable of a well-illustrated quartet of travel books on Mediterranean lands is R. A. N. Dixon's enthusiastic SPANISH RHAPSODY (*Robert Hale*, 1955, 18*s*). Based on two holidays in Spain and a deep love of that country and its hospitable and friendly people, the book seems full of real, tangible things, with tales of Mr. and Mrs. Dixon's contacts with Spaniards of all classes, dancing gipsies and charcoal burners included, and of their visits to show places like the Escorial, the Prado at Madrid (incidentally they met two Australians who had been to the capital but knew nothing of the great museum and gallery, being forever shocked by Spanish sanitation), Granada with the famous Alhambra, as well as less popular places like the Andalusian Antequera and Seville in summer. A great lover of Spanish wines, Mr. Dixon is also a bullfight fan.

Both informed and informative, as is usual with this travel writer, is Eric Whelpton's THE ROAD TO NICE (*Robert Hale*, 1955, 18*s*). This book is full of passages of unusual literary and historical interest. Mr. Whelpton's journey takes him south through Amiens with its unforgettable cathedral, via Senlis and Fontainebleau to the remarkable city Le Puy, on to Tarascon and Orange thence around a myriad of places full of memories of past seekers after the sun, artists and writers alike, then back north through the nearly Swiss or sometimes even German towns of the French Alps. Mr. Whelpton always has an eye open to natural beauty, any kind of curiosity and especially for architecture, and he savours the food and drink of many different regions with unfailing appetite.

The versatile Louis Golding's GOODBYE TO ITHACA (*Hutchinson*, 1955, 21*s*) is a book for lovers of the classics, or more particularly, of Homer, describing the author's search to follow the journeyings of Odysseus among the Greek islands, a project he had long cherished but been unable to carry out.

Of greater purely geographical interest is another finely produced volume in the *Beaux Pays* series, where good photographs on excellent quality paper are an important feature, a scholarly and very French study on ALGERIA (*Nicolas Kaye*, 1955, 30*s*) by H. Isnard. This work is by no means as far removed from present-day realities as might at first be imagined from the avoidance of the political. The study is confined to the northern, coastal and fertile part of the country for the main part, and one travels methodically from east to west, never forgetting that this too was part of the cradle of civilization and Phoenicians, Romans especially, Berbers, Turks, Spaniards and many others besides the French have left their marks. Islam has vied here with Christianity since ancient times. Later one goes inland as far as the high tablelands.

L. R. W.

THE UNEVEN ROAD. By LORD BELHAVEN. *London: John Murray*, 1955. $8\frac{1}{2} \times 5\frac{1}{2}$ *inches;* viii+355 *pages; maps and illustrations.* 21*s*

The Western Aden Protectorate is now an unhappy place with much of the friendship between Britons and Arabs dissipated. When Lord Belhaven first strode into it in 1931 as a subaltern in the Aden Protectorate Levies things were different. The people were untamed, anarchic, but they were friends with us and trusted us, and to no man did they give more friendship than the "Father of Baldness." Lord Belhaven speaks of the gulf between these people and us, but for all that he was huge and red, and they were small and brown, he bridged it.

He who gives his affections and understanding to Arabs has no reason to expect a smooth passage and when Ham stepped aside from the track which had led him through Eton and Sandhurst to the Royal Scots Fusiliers he found it rougher than most. The greatness with which he faced adversity shows through his modest writing. He has been described as an Elizabethan and compared to Odysseus: his kind is rare but belongs to no particular age or country. In the Protectorate he became part of the era which marked the change in Arab feelings and had a share in many of the events which had significance. He was in Sana for the signing of the treaty in 1934, he raised the Tribal and Government Guards, the pacification of Subeihi country was his and he inspired thoughts of peace and friendship for Britain in an area from which a Roman Legion had turned away defeated two thousand years before. His reward is in the feelings of these people for him and he has become a part of local legend. The essential Arabia was the poorer when he left: it was a thing of grief which baffles adequate analysis. A whimsical fate then led him to govern an Italian Province, and has now left him, in some bewildering way, tending obstreperous pigs in Galloway.

The sincerity, truth and honesty of purpose which run through these pages made the wild men of the South Arabian scene admire and respect him. It is not easy for those whose outlook stems from life in fertile lands to like a philosophy so different, but Lord Belhaven is an admirable interpreter. He writes with a great sensitivity, and sense of humour, much understanding and generosity. There is little that has been written about this country, except perhaps Wyman Bury's 'Land of Uz,' to compare with this book and his two previous ones, 'The kingdom of Melchior' and 'The eagle and the sun,' for giving the authentic flavour of this country. His history is intuitive and evocative. He showed in 'The eagle and the sun' that he can live in the past he sees so clearly. Whether he sees it accurately or not does not seem to matter—it could have been. His portrayal of the region as Eden embellishes our concept of it.

One cannot, however, draw favourable auguries for the success of an administrative federation among Aden States from the ancient Confederation of Ma'in. That developed when the Minaeans were fugitives and in decline. There are a number of these confederations today which imply little more than combination against external attack. Arab individualism gives no promise of unity and cooperation for constructive ends. As Lawrence once wrote, to talk of Arab federation is to talk fantastically. Indeed the suggestion of it did much to bring about the present state of affairs. H. I.

THE SOCIETY'S NEWS

MEDALS AND AWARDS, 1956

Her Majesty The Queen has been pleased to approve the award of the Royal Medals as follows: *The Patron's Medal* to John Giaever, leader of the Norwegian-British-Swedish Antarctic Expedition (1949–52) for contributions to polar exploration. and *The Founder's Medal* to Charles Evans, leader of the Kangchenjunga Expedition 1955 for contributions to Himalayan exploration. The Council have awarded the *Murchison Grant* to Dr. Alice Garnett, for contributions to physical geography and geographical education; the *Mrs. Patrick Ness Award* to Robert Dovers, Australian National Antarctic Research Expedition, for contributions to Antarctic exploration and mapping; the *Gill Memorial* to R. A. Skelton, Superintendent of the Map Room of the British Museum, for studies in the history of cartography and exploration; the *Back Grant* to Richard Hamilton, O.B.E., chief scientist, British North Greenland Expedition (1952–54); and the *Cuthbert Peek Grant* to David Oates, Fellow of Trinity College, Cambridge, for archaeological surveys in 'Iraq.

GRANTS TO EXPEDITIONS 1956 FROM THE SOCIETY AND THE *GEOGRAPHICAL MAGAZINE* TRUST

The Council has approved grants for 1956 totalling £1055, to 17 expeditions out of the 26 which applied. This sum represents £500 out of general funds, £380 from the Exploration Fund, £100 from the Penruddocke and £75 from the Stephens Bequests. In addition, recognition has been accorded to two expeditions and instruments loaned to one not otherwise assisted. As usual, the majority of the projects have been planned by university groups: Cambridge is combining with Oslo University in north Norway and receiving £50; other Cambridge expeditions are to Nyasaland (£50 from the Stephens Bequest, and instruments), an ecological expedition to Macedonia (£25 from the Stephens Bequest), north Persia (£50, and instruments), to north Borneo (£100), and the Cambridge Mountaineering Club has received £50 for their projected visit to east Greenland. Oxford and Cambridge combine for an expedition to northern 'Iraq and receive £50, and Oxford, Liverpool and Bedford College, London have a joint plan to go to west Greenland for which a grant of £100 is allotted. Oxford expeditions are to 'Iraqi Kurdistan (£100, and instruments), south-eastern Turkey (£50) and Socotra (£100 from the Penruddocke Bequest, and instruments). University College London receives £30 for the North Sweden Research Group and Durham University £50 towards expenses in the Lyngen Peninsula. In addition to these university ventures, the Council approves £50 and instruments to the Ratang–Parbat Himalaya Expedition, £50 and instruments to the British Expedition to Peru, £100 to H. J. Savory's researches into land use and peasant economy in Yugoslavia, and £100 to Wilfred Thesiger for his forthcoming visit to Afghanistan. Recognition is accorded to the Parachute Brigade Expedition to Alaska and to J. C. Jewell's British Andean Expedition; instruments have been loaned to the Bristol University Expedition to Iceland.

The *Geographical Magazine* Trustees approved the following grants: Cambridge expedition to north Persia, £50; Cambridge expedition to north Borneo, £50; Oxford and Cambridge expedition to northern 'Iraq, £100; Ratang–Parbat Himalayan expedition, £20; Cambridge Nyasaland expedition, £50; Oxford expedition to Socotra, £150.

The total of grants is thus £420. In addition to grants from the Society and the Trustees, many expeditions (including several of the above) received grants from the Mount Everest Foundation, set up by the Society and the Alpine Club, for exploration and research in mountain regions. Particulars of these are not yet available.

EXPEDITIONS IN THE FIELD, 1955

Some reports, additional to those summarized in the *Journal* for March 1956, have been received from expeditions to which the Society made grants in 1955 (see *Journal* for June 1955). These reports have been deposited in the Library where they may be consulted.

1. CAMBRIDGE AUSTERDALSBREEN EXPEDITION, 1955

Mr. W. V. Lewis has submitted a preliminary report of his party's work in Norway during the summer of 1955. Some interesting results were obtained from the glacier tunnelling, which proved more difficult than the work in mid-Jotunheim in 1951, partly because of the compact nature of the ice, but mainly to the rate at which the tunnel tilted owing to the rotation of the ice mass. Explosives were used to expedite penetration, and found reasonably satisfactory. The fact that the 400 feet of aluminium piping, specially ordered, did not arrive made modifications of the programme necessary, and plans are on foot for melting the pipe into the glacier ice fall this summer. Exceptionally fine, hot weather caused an unforeseen amount of ablation, 50 feet of the glacier snout melting away during the time spent in the field.

2. OXFORD UNIVERSITY EXPEDITION TO BORNEO, 1955–56

A report from Guy Arnold, leader of the expedition, was received dated 17 September 1955, which described the establishment of the party at their base camp at Rumah Kesing, on the upper Rejang river, Sarawak. Mr. Arnold is now back in England and will issue a full report on the Expedition in due course.

3. THE OXFORD AND CAMBRIDGE FAR EASTERN EXPEDITION, 1955

This Expedition received £100 from the Society in June 1955, too late to be included in the main list of grants already published. The party of six graduates from both universities, led by Timothy Slessor of Cambridge, left England on 1 September 1955 with a ten-months' programme, to be summarized as follows:

1. To undertake studies of certain economic developments in Pakistan and Burma which have occurred since 1947: that is, to make a geographical study of the Thal Desert Development Area and the Lower Sind Irrigation Area in West Pakistan; and a study of the present rice export economy of Lower Burma.

2. To complete the journey overland to Singapore via Burma in order to demonstrate the feasibility of this route. The party is travelling in two Land Rovers, and is sending home progress reports from time to time.

CORRECTION

The Editor regrets that there was a misprint in the report on the Oxford University Expedition to North East Land, 1955, in the *Journal* for March 1956. Page 125, line 11 of the relevant paragraph should read: "... and negative ice temperatures to a minimum of $-9°$ C. were" and not, as printed, $-90°$.

THE RECORD

CONTRIBUTORS TO THIS ISSUE OF THE *JOURNAL*

Major-General J. C. T. Willis, member of Council since 1952, was appointed Director-General of the Ordnance Survey in 1953. *Dr. P. H. Davis*, lecturer in botany at Edinburgh University, has travelled extensively in the eastern Mediterranean; he has just returned from his seventh Anatolian journey and is writing a Flora of Turkey. *Professor A. Leslie Banks* is Professor of Human Ecology and head of Department in the University of Cambridge. *Dr. S. Y. Landsberg* was an assistant lecturer in the Department of Botany, Aberdeen University, where her main research interest has been the Sands of Forvie, Aberdeenshire, from an ecological and geographical point of view. *David Oates*, Fellow of Trinity College, Cambridge, who receives the Cuthbert Peek Grant for 1956 for his archaeological surveys in 'Iraq, is engaged in revising the late Sir Aurel Stein's MSS. on the historical geography of northern 'Iraq. *R. A. Hamilton* was chief scientist to the British North Greenland Expedition. *Dr. C. A. M. King*, lecturer in Geography at Nottingham University, is at present visiting lecturer in the same subject at Canterbury University College, University of New Zealand, for 1956. *Richard Hill* is lecturer in Modern Near Eastern History in the University of Durham, and was formerly of the Sudan Service.

UNIVERSITY NEWS

DEPARTMENT OF GEOGRAPHY, KING'S COLLEGE, UNIVERSITY OF DURHAM, NEWCASTLE UPON TYNE

The recent period has seen the continuing expansion of post graduate research and the further application of geography to physical, economic and social problems. The study of West Durham carried out with the aid of a grant from the Nuffield Foundation and under the supervision of Professor Daysh, has been completed and the results published. A survey of Teesside is now in progress under the supervision of Mr. House and Mr. Fullerton, the finances being provided by the North East Industrial and Development Association and the Teesside Industrial Development Board. Mr. House has also carried out particular studies of rural Northumberland, for example, in conjunction with the Northumberland Rural Community Council. At the request of the Marquess of Normandy, Professor Daysh (now the Sub-Rector of King's College) has organized a special survey of Whitby. Members of the team now engaged upon this survey include Commander Fryer (Reader in Surveying), Mr. House and Mr. Conzen together with Mr. Allen of the Durham Colleges, Dr. Hemingway of the University of Leeds and Mr. Appleton of the University of Hull. Mr. Anson and Mr. Sharp (who joined the staff of the Department in 1954 as lecturer in Geography and Surveying), with generous financial aid from Imperial Chemical Industries and from King's College are investigating the climate and hydrology of the Tyne catchment basin. Apart from such joint investigations, personal research by staff members continues. Mr. Conzen has made progress with his studies in the morphology of towns and some results will be published by the Department in the near future. Mr. House has completed work in the Massif Central, on the Schuman Plan and on the nineteenth century population geography of north-eastern England, the latter being the first of a series of Departmental Research Publications. Mr. Anson continues his work in the fields of geomorphology, climatology and cartography. Mr. Fullerton, who joined the Department in 1954 from the University of Glasgow to replace Dr. Mather, who is now in Australia, is working on geographical aspects of the occupational structure of Britain, having completed research into the limits of cultivation in northern Sweden. Mr. Sharp has extended his interests in the field of physical geography and accompanied a geographical research team to Norway during

the summer of 1955. Research students currently attached to the Department are studying manufacturing industry and regional development problems in Egypt, the social geography of Cyrenaica, economic geography of north Teesside, the mineral resources and population geography of Cumbria, and the ecological geography of the northern Pennines and dales. Ph.Ds. have been successfully completed during the past session, on the Tyne ports, the economic geography of the Tyne gap, the growth and function of Carlisle and the Qaliobia Province in Lower Egypt. There has been an even greater development in the number of students reading for Master's degrees, a notable recent thesis being on sixteenth century Venezuela (M. Litt.).

The teaching life of the Department has expanded into new fields, though undergraduate numbers have remained fairly constant during the past few years: Political Geography and Biogeography have been added to the list of special options available to Honours Students. Foreign excursions have taken groups to the Netherlands and Belgium, with an emphasis upon the comparative study of regional and economic problems. Posts obtained by graduates have increased in variety and availability, with greater numbers than hitherto taking employment overseas, in educational, administrative or commercial life. The Department has been fortunate to welcome distinguished geographers and other overseas visitors as its guests, some of the most recent including Professor Tulippe of Liège, Professor Keuning of Gröningen and Professor Allix of Lyons. Particular mention must be made of the fact that the University of Durham has conferred honorary degrees upon Professor F. Debenham and Professor W. E. Boerman of Rotterdam in recognition of their great work for geography. The opportunity may be taken to mention the University of Durham Exploration Society, an activity drawing support and strength from almost every Department in the University. The Court of the University makes an annual grant to the Society and commonly two overseas and two training expeditions are organized each summer. Former members of the Society, Mr. H. Lister, Mr. D. Peacock and Mr. P. Taylor were members of the British North Greenland Expedition and were subsequently recipients of the Polar Medal. Mr. H. Lister has been appointed to the new lecturership in Polar Studies in King's College and will take up his duties here in July, joining the Trans-Antarctic Expedition later in the year. This Lecturership has been made possible by a most welcome grant from the Nuffield Foundation

J. W. H. AND G. H. J. D.

SCHOLARSHIPS AT OXFORD, 1956–7

A geography scholarship examination will take place in December, beginning on Tuesday, 14 December 1956. The colleges concerned are: Hertford (one open scholarship), Jesus (one open scholarship, one Welsh Foundation scholarship, and one open exhibition), Pembroke (one open scholarship and one open exhibition), and St. Edmund Hall (two open scholarships).

Geography will as usual be one of the subjects included in the Modern Subjects Examination held during Hilary Term. The colleges concerned are: Balliol, Corpus Christi, Magdalen, New College and University College.

An award in geography may be made by St. Catharine's Society at its examination to be held during April 1957.

Geography scholarships and exhibitions may be awarded by any of the women's colleges on the results of the examinations held in November 1956 at St. Hugh's and St. Hilda's Colleges, or at Somerville and Lady Margaret Hall; and in January 1957 at St. Ann's College.

The issues of the *University Gazette* giving details of all Scholarships offered in the University will be published early in July. That for the men's colleges cost 1*s* and that for the women's colleges 6*d*; they can be obtained from the Oxford University Press, High Steet, Oxford.

Editorial Note: The Editor hopes to receive further items of University News for publication in the September *Journal*, from foreign as well as British universities.

These, preferably, should not be restricted to departmental news, new appointments and so on, but should include information about new research projects, and about the progress of existing projects.

UNITED STATES DISCOVERIES IN ANTARCTICA, 1956

Two items of interest were recorded from the zone of U.S. operations in Antarctica in the late winter and spring of this year. In January, the Society received a letter from a Fellow, Captain Richard B. Black, U.S.N.R., enclosing a letter and an Antarctic relic addressed to our distinguished Honorary Member, Sir Winston Churchill. The relic was a page of the *Bystander* for 5 February 1908 at the head of which was a vignette of a hunting party on safari. Among those present was Winston Churchill. At his feet lies the carcase of a rhinoceros, and the caption reads: "Bagged by Winston! A rhino shot by Mr. Winston Churchill at Simba, during his African tour." The letter to Sir Winston Churchill (from which we are allowed, by his kind permission, to quote) describes how the page was found, folded and wrapped round the stub of a home-made candle, inside a rusted tin. These relics were found in front of the hut erected at Hut Point, McMurdo Sound, in the Ross Sea Dependency, by Scott and used again by Shackleton during the British Antarctic Expedition of 1907–9. Our Fellow, Captain Black, commanded the East Base, United States Antarctic Service Expedition, in Marguerite Bay in 1939–41 and was a member of the wintering party during the Byrd Antarctic Expedition II in 1933–5. From December 1955 he served as Base Operations Staff Officer at McMurdo Sound, one of the bases for the present U.S. Navy Operation "Deepfreeze I."

A scientific discovery of special interest to readers of this *Journal* was made this season by the United States Expedition, in the form of a great trough flanked by high mountains, on the ice cap between Victoria Land and Wilkes Land. The probable existence of such a mountainous channel in the lofty, ice-covered interior of Antarctica in the sector was predicted by Mr. H. H. Lamb of the Meteorological Office and Instructor-Commander G. T. Britton, R.N., jointly, in a paper appearing in the *Journal* for September 1955, on the basis of clear evidence of strong topographical effects on the atmospheric circulation in the Antarctic. Peculiarities of wind-flow are often explicable from the geography of the regions in which they occur, but this is believed to be the first time that the argument has been successfully used in reverse, and meteorological evidence used to predict the discovery of a major geographical feature.

BRITISH NORTH GREENLAND EXPEDITION, 1952–4

Some of the scientific findings of the North Greenland Expedition are covered in papers printed in this *Journal* (pages 205–40). The medical and physiological aspects were dealt with in three issues of *Lancet*, 3, 10 and 17 September 1955 (pages 494–500, 549–56, 591), in papers by Surgeon-Lieutenant J. P. Masterton, R.N.V.R. (Medical Officer to the Expedition) and Dr. H. E. Lewis, Medical Research Council (physiologist). The two longer papers have been issued as a reprint, and the third, a note on "Trichinosis in Greenland," as a leaflet. Living arrangements, clothing and food are exhaustively discussed, an important section being devoted to sanitary and washing facilities, with some simple and practical suggestions for improvements in hygiene and comfort. The authors discuss general considerations of well-being, stressing the absolute necessity of certain aspects of selection of personnel, and extremely detailed medical examination. Instruments, drugs, dressings and first-aid kit are listed at length; medical problems are analysed and minor incompatibilities of personality discussed, but it would seem that the dreaded "cold injuries" (frostbite, snow blindness and exposure) caused little trouble because of preventative care. A paragraph headed "Unexpected" lists a wide variety of cases, including tropical disease, but the accident rate was low. Members of the expedition cooperated in the physiological research programme to a most creditable extent, submitting themselves

to various disagreeable routines—being woken three or four times in the night, being subjected to pinches for fat-thickness measurements, and having blood drawn; it is drily observed that occasionally "some members became disenchanted with the physiological programme." A succinct list of recommendations for future expeditions concludes this most interesting study of men living and working in the polar regions.

THE FALKLAND ISLANDS AND THEIR DEPENDENCIES

We have received from Dr. D. Dilwyn John a note on Sir Miles Clifford's recent paper in the *Journal* on the Falkland Islands (December 1955, pp. 405–16). Dr. John served in the *Discovery* Investigations from 1925 to 1935, and the paper read by him to the Society on "The second Antarctic Commission of the R.R.S. *Discovery II*" was published in the *Journal* for May 1934 (Vol. 83, no. 5, pp. 381–98). Dr. John writes: "In the issue of the *Geographical Journal* for December 1955 there is an interesting and most informative article by Sir Miles Clifford on 'The Falkland Islands and their Dependencies.' It was the subject of an address to the Society in May 1955, and contains an account of the history of the colony and of British activities in the Dependencies. Since it is written by a former Governor of the Falkland Islands it will surely be accepted as authoritative, and will be widely read among those who are interested in Antarctic exploration and research. For these reasons it seems important to draw attention to a strange omission in a paper which, if I may say so, seems otherwise so well balanced, and which covers so many interesting topics.

"After dealing with the Falkland Islands the author refers to various Antarctic expeditions, especially those which worked in the Dependencies. The expeditions of the *Belgica*, *Antarctic*, *Français*, *Pourquoi Pas?*, *Deutschland*, and *Endurance*, Ellsworth's trans-antarctic flight, and the British Graham Land Expedition, all receive attention; and the last two pages are devoted to the Falkland Islands Dependencies Survey (F.I.D.S.). It seems very remarkable that in all this the work of the Discovery Committee, which has contributed so much to modern knowledge of the Antarctic in general and the Dependencies in particular, is not even mentioned. I write as one who ceased to participate in that work twenty years ago but who has never ceased to be interested in it. It is certain that someone should comment on a paper on the Falkland Islands and their Dependencies which omits all reference to the Discovery Committee and yet purports to be comprehensive. It is true that the Discovery Investigations were concerned with research rather than with geographical exploration, but it is clear from Sir Miles Clifford's account of the work of the F.I.D.S. that he does not regard the discovery of new land as the only matter of significance in the work of expeditions in these regions. It is therefore quite extraordinary that he should say (on p. 411) "The only antarctic achievements of note between the wars were Lincoln Ellsworth's remarkable trans-antarctic flight . . . and the British Graham Land Expedition." The *Discovery*, *Discovery II*, and *William Scoresby*, and sections of the staff working in whaling factories and elsewhere, were at work in the south between 1924 and 1939. Research on whales had a prominent part in the programme but it was only partly to this end that the ships were engaged in a widespread plan of oceanographic exploration, coastal surveys and soundings, investigation of the natural history of the Antarctic (especially the Dependencies) and many subsidiary matters. Most but not all of the results are published in the Discovery Reports of which twenty-seven volumes have appeared so far. I will not attempt to summarize all that has been done, but should like to draw attention to some achievements in the Antarctic which have advanced what is known of the Dependencies and cleared the way for more recent work in that region.

"The Discovery Investigations have been little advertised and it is probably not well known that they are unique in having covered the whole Southern Ocean with a network of observations at all times of year. It is not too much to say that the Committee's ships have contributed more than all others combined to what is known of the currents and water masses, the physical and chemical variables, and the plank-

tonic fauna and flora of the Antarctic seas up to the Antarctic coasts; and the most intensive observations were made in the waters of the Dependencies. Such knowledge is of basic importance to other investigations, for example on the populations of animals of actual or potential economic importance or on Antarctic meteorology. Both scientists and navigators must consult the Discovery Reports for information on the broad distribution of the pack ice and its seasonal ebb and flow, whether in the Dependencies or elsewhere. There must be few if any Admiralty charts of the Dependencies which have not large or small contributions from the *Discovery* and *Discovery II*. Running surveys of the South Sandwich Islands and substantial parts of other island groups have considerably improved the mapping of much of the Dependencies, but the charting of harbours and anchorages, especially in South Georgia and the South Shetland Islands is probably of more lasting value, for some of the running surveys will no doubt be superseded by the work of the F.I.D.S. since that organization is primarily concerned with the land. Undoubtedly the *Discovery II* has contributed more than any other ship to existing knowledge of the bottom topography of the waters of the Dependencies, and this is important not only to navigation but to any proper understanding of the oceanographical conditions and the distribution of the marine fauna. The 'Antarctic Pilot' issued by the Admiralty, is perhaps the best existing text-book on the Antarctic seas and coasts, and a perusal of the edition of 1948 will show how heavily the compilers have drawn on the information and experience supplied by the Discovery Investigations.

"When the Discovery Committee began its work the Dependencies were the world's most important centre of whaling. That industry has since spread round the whole Antarctic and the Committee's field of work expanded accordingly, but whaling is still the only important industry in the Antarctic and is still pursued in the Dependencies; and I believe it is true to say that the Discovery Committee and the National Institute of Oceanography (which continues its work) have done more than any other body to supply the biological information needed for the proper regulation of whaling. I need not enlarge on the mass of other information presented in the Discovery Reports—the monographs on many groups of the marine fauna, the results of trawling surveys in the Falkland region, the descriptions and history of the South Orkney and South Sandwich Islands, and the papers on seals and birds, and on many subsidiary matters. The scientific value of the work is unquestioned and although few people who are not scientists can be expected to study these massive reports in detail, even a glance at the papers in the *Geographical Journal* itself which have described the voyages of the ships from time to time, should be enough to show the ground covered and the extent of the oceanic and coastal surveys which have been carried out in the Dependencies and other parts of the Antarctic.

"The work of the Discovery Committee and of the Falkland Islands Dependencies Survey are surely in many ways complementary to each other. The former was reorganized under the N.I.O. in 1949. The latter began I believe in 1944 and it is noteworthy that the first field bases were established under the leadership of J. W. S. Marr, a member of the Discovery Committee's staff. (See J. M. Wordie's account of the F.I.D.S. in the Polar Record, No. 32, 1947.) Furthermore my recollection is that three or four other members of the first field parties formerly worked also under the Discovery Committee. I do not know whether or to what extent the initial organization and scientific programmes of the F.I.D.S. may have otherwise benefited by the experience of that Committee and its staff. If it has so benefited—and it would be extraordinary if it has not—it seems curious that Sir Miles Clifford, who has so much to say about the F.I.D.S., should treat the Discovery Committee as if it had never been. I have said earlier in this note that the Discovery Investigations have been little advertised. Perhaps more should have been done to make the work better known and understood; but it may be, on the other hand, that the Discovery Committee was wise not to seek publicity and to leave the value of its work to the judgment of time and of informed opinion."

D. DILWYN JOHN

THE INTERNATIONAL GEOGRAPHY SEMINAR, ALIGARH, 1956

The Aligarh Muslim University, long a pioneer of advanced geographical studies in the Indian sub-continent, recently took the bold initiative of holding an International Geography Seminar (9–16 January 1956). The experiment, backed by the Indian Universities Commission, was an outstanding success. Altogether around 100 Indian geographers attended, with a contingent from Pakistan, and 53 from other countries. The biggest single foreign contingent was led by Academicians Gerasimov and Salitschev from the U.S.S.R.; altogether there were 26 delegates from politically "Eastern" countries as against eight representatives of the West. These figures should give food for thought. Of the intermediate countries, Egypt perhaps was most prominent.

The Seminar was magnificently organized. The note was struck immediately by the splendid decoration of the hall where the main sessions were held: maps of the countries represented superimposed on their national flags and linked by streamers to the position of Aligarh on a central map of India. After a witty welcome by Dr. Zakir Hussain, Vice-Chancellor of the University, Shri K. D. Malaviya, Minister for Natural Resources and Scientific Research, delivered the inaugural address. The full extent of the careful planning, down to the provision of headed memo paper, was not realized until the sessional meetings began. The only omission, equally and severely felt by the Soviet and the Australian representatives, was a rubber-stamp for autographs.

The actual sessions, with their Chairmen, were as follows: Geography in National Reconstruction (Gerasimov, U.S.S.R.); National Reconstruction: (i) Hydro-electric Development (Ahmed, Pakistan), (ii) Land Use Survey (Chatterjee, India); Teaching, with special reference to Post-Graduate Training (Geddes, U.K.); Food Resources and Population (Sun, China); Climatic Changes (Huzayyin, Egypt); Arid and Semi-arid Zones (Sain, India); Geography and Racism (Spate, Australia). It is of course impossible to summarize the wide range of papers presented: in general, the most interesting aspects of the Seminar were the opportunities of finding out at first hand something of the outlook and methods of Soviet geographers, and the very remarkable advance in maturity and sophistication of technique shown by the Indian and Pakistani contributions, as compared with the situation only ten years ago.

The success of the Seminar gave rise to a desire to form some permanent organization to foster geographical studies in the context of the under-developed countries of Asia and Africa. Professor Huzayyin was enthusiastically elected President, with five Vice-Presidents from Asian countries: Dr. Zakir Hussain (India), Professors Kazi Ahmed (Pakistan), Sun (China), Takano (Japan), and Academician Gerasimov (U.S.S.R.). The Committee forthwith decided to co-opt Professors Stamp (U.K.), Cressey (U.S.A.), Dresch (France), and Spate (Australia).

Hospitality was almost overwhelming. Perhaps the high spot was the concert at which Muslim students, boys and girls, sang with lusty enjoyment Hindu folk songs in honour of Sri Krishna, to music composed by His Highness the (Muslim and mediated) Nawab Sahib of Rampur. More seriously, the Seminar undoubtedly marked a great advance in geographical studies in the Indian sub-continent, and the initiative of the Aligarh Department of Geography calls for the unstinted admiration of all those interested in Asian geography. It is to be hoped that any similar meetings in the future will receive more support from the West. O. H. K. S.

THE IRISH EMIGRATION COMMISSION

After six years' work, this Commission has published its report.[1] Of its twenty-two members only four agreed to the findings without reservation, and two produced long minority reports, one of which, by Mr. James Meenan, the economist, is worthy of close study. All deplore a permanent acceptance of emigration as inevitable; but

[1] Commission on Emigration and other Population Problems, 1948–54. Stationery Office, Dublin, 1955. 12*s* 6*d*.

it is agreed that its prohibition is unpractical. The problem is therefore to make life at home more attractive and remunerative. Between 1926 and 1951, the total amount of employment changed little: a decline of 147,000 in agriculture was offset by an increase of 164,000 in other, primarily industrial, employment. And the total population of the country remains stable, at almost three millions, for the emigration is practically equal to the natural increase. The farm population is still declining in excess of the demand for industrial workers and this trend seems likely to continue. Mr. Meenan advocates that capital should be used on the land rather than deposited in the bank, that soil fertility should be scientifically developed and small farm production intensified by concentration on milk, pigs and poultry. "The stagnation in agricultural production," he adds, " is the crucial problem of the national economy." More cautiously, the majority report, while agreeing that things could be improved, advocates a "Land Utilisation Body," designed to make investigations similar to those of the Survey in England but also to deal with transport, land tenure and succession: the ideas here given suggest a rural planning authority. Excellent in theory, this suggestion raises administrative problems. Afforestation in the least-forested country of Europe (except Iceland) offers hopeful prospects but fishing is in a depressed state, partly because the annual average consumption per head is only 10 lbs. compared with 40 lbs. in Britain. Ranging over wide problems, this Report considers social amenities such as village halls, and rehousing: it recommends that new cottages should be built in groups so that they can be more easily given piped water supplies and electricity. The rapid growth of Dublin and the stagnation of almost all the other towns led to the suggestion that many more industries and some civil service departments should be moved to the provinces. There appears to be no new problem and no new solution: the Report is chiefly interesting as a study of the effects of emigration on a country exporting people. The challenging fact that one out of every three persons born will leave Ireland is held to weaken national pride and retard national progress. T. W. F.

CONGRESS OF HUNGARIAN GEOGRAPHERS

Delegates from the U.S.S.R., Poland, Czechoslovakia, Romania and Bulgaria were invited by the Hungarian Academy of Sciences to attend a Congress of Hungarian geographers held in Budapest from 19 to 23 September 1955. At the Congress it was announced that Faculties of geography have been instituted in the following Hungarian universities: Budapest, with a total staff of 21: Szeged (staff of 7); Debrecen (staff of 6); and Pecs (4). An Institute of geographical science and research has been opened in the Academy of Sciences, Budapest, with a staff of 22. All geographical research in Hungary is planned by a Central Geographical Committee of 12 members, which has recently issued a Five-Year Plan for research in geography. The Hungarian Geographical Society, founded in 1872, ceased to function in 1945 but has now been resuscitated and has, at present, 2500 members. (*Abstracted from Izv. All-union geogr. soc.* 1956 : 1.)

RECENT SOVIET ATLASES

Some of the atlases published in the U.S.S.R. since the war have become available in this country through Collet's Russian Bookshop (Museum St., London, W.C.1). Listed below are recent editions of some of the more useful available atlases, all of which are published by the Chief Directorate of Geodesy and Cartography (Glavnoye upravleniye geodezii i kartografii MVD SSSR), Moscow.

1. Historical Atlas of the U.S.S.R. for Middle Schools (Atlas istorii SSSR). Moscow, Parts 1 and 3 1954, Part 2 1955. $9^{1}/_{2} \times 12$ inches. Part 1 (Stone Age–1689) 24 pages of maps; 5 page index. Part 2 (1689–1900) 22 pages of maps; 5 page index. Part 3 (1900–1950) 52 pages of maps; 7 page index. Parts 1 and 2, 5*s* each. Part 3, 8*s*.

2. Atlas of the World (Atlas Mira). Moscow, 1954. $20 \times 13^{1}/_{2}$ inches; 283 pages of maps. Index: $11^{3}/_{4} \times 9$ inches; 555 pages. 16 *gns*.

3. Atlas of the World (Atlas Mira). Pocket edition. Moscow, 1955. $5 \times 7^{1}/_{4}$ inches. 157 pages of maps; 15 pages of tables; 125 page index. 20*s*.

4. Geographical Atlas of the U.S.S.R. for the 7th and 8th Classes of Middle Schools (Geograficheskiy atlas SSSR dlya sed'movo i vos'movo klassov sredney shkoly). Moscow, 1953. $9^{1}/_{4} \times 11^{3}/_{4}$ inches. 60 pages of maps; 14 page index. 9*s*. (Referred to below as the School Atlas.)

5. Geographical Atlas for Middle School Teachers (Geograficheskiy atlas dlya uchiteley sredney shkoly). Moscow, 1954. $10^{3}/_{4} \times 15$ inches. Introductory section I–VII; 156 pages of maps; 35 page index. 32*s* 6*d*. (Referred to below as the Teachers' Atlas.)

6. Atlas of the U.S.S.R. (Atlas SSSR.) Moscow, 1955. $8 \times 10^{1}/_{2}$ inches. 76 pages of maps; 71 page index. 25*s*.

1. *The Historical Atlas of the U.S.S.R. for Middle Schools* is in three parts, each of which is composed mostly of war maps and maps showing the growth of the Russian state at different periods. Of particular value to geographers is a number of economic maps; for instance, in Part 1 a map for the second half of the seventeenth century distinguishes areas predominantly devoted to fur-trading, nomadic herding, corn-growing and flax and hemp cultivation, and indicates eight kinds of industry by symbols. The economic map of Russia on the eve of the 1861 reforms (Part 2) shows the distribution of serfdom by choropleths. Proportional symbols indicate the number of workers in industrial centres. The development of industry and transport in the period 1861–90 is shown on another map, together with the numbers of employees and the value in 1897 of imports and exports moving by different land and sea routes. The latter are given in millions of roubles, but there appear to be discrepancies between the 1949 and 1955 editions of the atlas.

Part 3 is of most value, for it contains maps showing the Soviet development of power supplies, industry, transport and collectivized agriculture before the Second World War. In contrast to those for *c.* 1860 and *c.* 1890, the economic map for 1913 shows industrial centres by symbols of uniform size. Finally, there are maps showing industrial reconstruction and development planned for 1946–50, and agricultural regions. An inset map indicates the total Soviet capital investment for 1946–50, but the distribution dots apply unfortunately to investment only in reconstruction and not in new developments. An inset map in the 1952 Edition showing the Shelter Belts of the Volga–Don area planned for 1949–65 has been omitted from the 1954 edition.

2 and 3. The large *Atlas Mira* is reviewed in this issue, on pp. 252–4. The pocket edition, however, deserves a separate comment, since it is by no means a small copy of the large library atlas. It contains no topographical maps other than those of the world and continents, but a limited amount of hill-shading is used on the politico-administrative maps which make up most of the atlas. Physical and political maps of the world and a map of the time zones are followed by 41 pages of maps of the Soviet Union. Sixty-one pages of maps are devoted to the remaining parts of Europe and Asia whilst the rest of the world is covered in 50 pages. Considering the limited scales which have to be used in an atlas of this size, the maps bear a considerable range of detail concerning hydrography, boundaries, communications and the size and administrative status of towns and cities. For example, on the standard politico-administrative maps there are six symbols to show cities of different sizes in countries outside the Soviet Union, and four symbols for Soviet cities. The tables contain information of two main kinds, physical and political. The political tables give information concerning the size and population of countries, the population of capital cities and all other cities with more than 1 million inhabitants, in all parts of the world except the U.S.S.R.

4, 5 and 6. *School Atlas, Teachers' Atlas* and *Atlas SSSR.* The School Atlas and Atlas SSSR deal only with the U.S.S.R., but the Teachers' Atlas covers the whole world. All three contain useful topographical maps of the U.S.S.R. on scales larger

than those generally used in English-language atlases. Even the small School Atlas has maps of the more important parts of the U.S.S.R. on scales of 1 : 3 to 1 : 8 million. The Atlas SSSR is almost entirely devoted to topographical maps and uses scales as large as 1 : 1,500,000 for the Moscow and Leningrad regions, the Donbas, Crimea and Vale of Ferghana. Layer tinting is universally adopted in these three atlases. The maps in the Teachers' Atlas and the Atlas SSSR are printed more clearly than those in the School Atlas and more tints are used. Hill-shading is also used in mountainous regions and sometimes in hill country.

Economic maps of the U.S.S.R. in the Teachers' Atlas resemble those in the School Atlas but are more detailed. They fall into two categories: those of the whole of the U.S.S.R., usually single-topic maps; and those of each of the main regions of the country, which are comprehensive in scope. On these regional economic maps, types of farming are shown in different tints, while the principal concentrations of various crops and livestock are indicated by symbols. Mineral deposits are shown in the Teachers' Atlas on these economic maps, but in the School Atlas they are shown on the topographical maps. The main industry or industries of towns are shown by circles, coloured according to the main branches. These symbols are quantitative, but only a small number of sizes are used, thus giving only an approximate idea of the relative importance of each centre. The movements of commodities, particularly of ores and fuels, are indicated on the regional economic maps in the School Atlas by means of arrows; these are employed in the Teachers' Atlas only on a few of the single-topic maps. Sources used to compile the economic maps are not quoted. Despite this and other disadvantages, the maps are of the greatest value in any study of the economic geography of the U.S.S.R.

The systematic maps of non-economic topics in the Teachers' Atlas and School Atlas are not so outstanding, but are nevertheless of value, and in some particular cases, are unusual. For example, in the Teachers' Atlas a technique has been adopted which was used in the Great Soviet World Atlas, Vol. I (1937): two maps of each continent show the precipitation in the driest month of the year and in the wettest month, these months being indicated in various localities by Roman numerals. In addition there are maps showing the mean duration of the frost-free period, and maps of actual January and July temperatures, and annual rainfall and corrected annual temperatures, making up the series of six climatic maps for each continent.

In addition to its 61 pages of maps of the U.S.S.R., which undoubtedly form the section of greatest value, the Teachers' Atlas has 87 pages devoted to world maps and maps of the continents, among which the non-Soviet parts of Europe and Asia have a large share. The economic maps are of the same general style as those in the Soviet section, but there is not such a fine division of topics between separate maps. A typical lay-out for a country or continent includes two agricultural maps (one of regions, and one of important crops and/or livestock) and several industrial maps (*e.g.* extractive industries, metal and engineering industries, textile industries). In addition to economic and climatic maps, there are maps of population density, "peoples" (based very largely on languages), vegetation and geology, for each continent.

This Teachers' Atlas compares very favourably with English-language atlases in the same price range. Indeed, the atlases reviewed should all prove of interest and value to students of Soviet and international affairs, for they not only provide many illustrations of the geography of the U.S.S.R. not normally found in English-language publications, except in the recently published Oxford Regional Economic Atlas of the U.S.S.R. and Eastern Europe, but also help to cast light upon the Soviet outlook on education and world affairs. J. C. C., J. P. C. and D. R. M.

SOVIET GEOGRAPHICAL SERIALS IN THE SOCIETY'S LIBRARY

Bulletin (Izvestia) of the All-Union geographical society vol. 88 (1956). No. 1 (Jan.–Feb.) Congress of Hungarian geographers, Budapest, September 1955, by

S. V. Kalesnik. Metallurgy in India and a projected factory in Madhya Pradesh, by V. M. Shtein. Climatic character of the state of Madhya Pradesh, by N. N. Ivanov. Geomorphological map of the world, by A. S. Devdariani. A geomorphological analysis of the tectonics of the Carpathians, by M. I. Gerenchuk. Connections between the development of national economy, the distribution of manufactures and the process of formation of regions, by R. M. Kabo. Problems of content in a physical geography course in higher schools, by P. G. Kochergin. The syllabus in physical geography for geographical faculties in training colleges, by Y. A. Korepanov. The Nalivkin glacier (Arals), by N. L. Korzenevskii. Investigation of some river profiles in the Carpathians, by M. S. Kozhurin. River ice as a factor in relief formation, by V. G. Lebedev. An unknown copy of maps from the 'Atlas of the Russian Empire,' by Kirilov (1689–1737). List of books on geography and related disciplines added to the Library of the All-Union geographical society.

Bulletin (Izvestia) of the Academy of sciences of the U.S.S.R. Geographical series, 1956: 1 (January–February). Scientific work of Soviet geographers in the Antarctic, by V. K. Burkhanov. Geographical results of nutation in the Pacific, by I. V. Maksimov. Results of the study of tectonic movement in the western part of the European U.S.S.R., by A. V. Zhivago and others. Hydrography of the main watershed between the Pacific and Arctic, by S. S. Korshuev. Geomorphological structure of the north-west Pre-Caspian, by S. V. Pronicheva. Increased flooding of the Dniester as a factor in the contemporary trend away from the adjacent parts of the northern Black Sea coast, by K. I. Fatkin. The 'Black earth' zone in winter, by V. A. Nikolaev. High water in spring in the rivers Tura, Tobola and Irtysh, 1851–1950, by E. N. Grigorieva. Vegetation as indication of salt content in the Ust-Urt valley, by S. V. Viktorov. Distribution by the wind of certain types of grass, by R. V. Federov. Some problems of economic geography in the light of resolutions of the second Congress of the All-Union geographical society. Geography abroad: survey of 'American geography: inventory and prospects,' edited by Preston James. (28 pp.)

SHACKLETON'S IMPERIAL TRANS-ANTARCTIC EXPEDITION

A ceremony took place at the Society's House on 6 May 1955 to commemorate the anniversary of the day on which the *Aurora*, on the same date in 1913, broke away from her moorings and left stranded ten men of the Ross Sea party of Shackleton's Trans-Antarctic Expedition. The Editor regrets that in the account of this gathering, published in the *Journal* for September 1955 (page 373), it was stated that Professor A. Stevens of Glasgow University, who was present, was the last survivor of the Ross Sea party. A letter has been received from R. W. Richards, Principal of the School of Mines and Industries at Ballarat, Australia, which states that "Messrs. Keith Jack, Irvine Gage and the writer, all of this State, were members of the marooned shore party at Cape Evans. The writer is also the sole survivor of the Southern party that placed the most southerly depot for Shackleton at Mount Hope." We are very glad to have this opportunity of apologizing and for correcting our first statement.

CORRECTION: "THE STATE OF SOVIET GEOGRAPHY"

We have received a letter from Academician Grigoriev correcting a statement in his paper "The state of Soviet geography" in the *Geographical Journal* for December 1955, page 434. We are asked to substitute for lines 22–24 from the bottom of the page the following: "The periods when the general humidity was the highest in the last seven millennia coincided with the beginning of the sixth millennium B.C.; with the first third of the fourth millennium B.C.; with the end of the third millennium B.C.; with the second half of the first millennium B.C., and lastly, with the middle of the second millennium A.D."

NOTES

A copy has been received in the Library of a reprint of AUSTRALIAN ANTARCTICA, a paper read by Dr. Griffith Taylor on 16 April 1955 to the Royal Australian Historical Society, Sydney, and printed in the journal of that Society (Vol. 41, Part 4, 1955). Dr. Taylor, who holds the Polar Medal, was senior geologist on the British Antarctic Expedition 1910–13, and has been Professor of Geography at Sydney, Chicago and Toronto. The paper, illustrated by maps, tells briefly the history of Antarctic Discovery from the days of Cook and Biscoe down to the Australian National Antarctic Research Expeditions of recent years. It concludes with the author's firmly expressed opinion that air survey is more likely to disclose the secrets of the Seventh Continent than sledging across the surface.

* * *

Look and Listen, the journal of audio-visual aids to education, has sponsored a useful catalogue of 16 mm. educational films called SHOW THEM THE LAND. It is compiled by Charles A. Pratt and published at 62 Doughty Street, W.C.1, by the Cable Press. It contains the names of over 1000 films (sound and silent, colour and black-and-white) together with the addresses of distributors; a geographical and a subject index facilitate quick reference. It is claimed that careful use of the catalogue will save money, in revealing alternative and sometimes cheaper sources of supply.

* * *

An INTERNATIONAL CONFERENCE on the STANDARDS OF LIVING IN TUNISIA, held in Tunis from 10–17 October 1955, has issued a preliminary report. In the opinion of the Conference, poor natural resources cannot be held wholly responsible for the very low standards of life in Tunisia; more modern methods of agriculture and better irrigation would do much to improve the lot of the Tunisian peasant. The reform of land tenure systems in the country districts and some kind of protection for the traditional industries of the towns were among the remedies suggested by the Conference. The full findings will be published by the Institut des Hautes Études de Tunis in the series *Mémoirs du Centre d'Études de Sciences Humaines*.

* * *

A SUMMER SCHOOL IN HISTORICAL GEOGRAPHY, directed by Dr. H. Thorpe, is being organized by the University of Birmingham at Westham House, Barford, near Warwick, for the period August 11–18 this year. The course, which will study the evolution of landscape in the contrasting Arden and Feldon regions of Warwickshire, includes work in the field as well as on documentary sources. Copies of the complete programme may be obtained from The Director of Extra-Mural Studies, University of Birmingham, or from The Principal, Westham House, Barford, near Warwick.

* * *

CORRESPONDENCE

The Problem of Tors

May I join the contributors to the discussion of Professor Linton's paper on "The Problem of Tors" (*Geogr. J.* **121** (1955) 470) in admiring the close observation, evocative description and careful deduction it exemplifies? I write in general support of Professor Linton's thesis by drawing attention to an Australian example, which may well be unknown to many readers of the *Journal*. At Roughtor in Cornwall on a field meeting a few years ago, I remember conveying to our students (though they without doubt will have forgotten it!) the gist of the "two-cycle" theory of tor formation as expounded in the relevant Geological Survey sheet memoir (C. Reid, G. Barrow and H. Dewey, 'The Geology of the Country around Padstow and Camelford,' H.M.S.O., 1916). But of course one finds only the gist there and Professor Linton has valuably elaborated and, to my mind, convincingly demonstrated this "two-cycle" theory.

However, the ideas in the Survey Memoir prepared me to accept readily a similar explanation of the tors of the Monaro plateau in New South Wales proffered by A. B. Costin ("Mass Movements of the Soil Surface with Special Reference to the Monaro Region" (*J. Soil Conservation Service N.S.W.* **6** (1950) 75)). "Tor" seems to have acquired a slightly different connotation in Australia and commonly applies in a restricted sense to perched boulders in coarse-grained crystalline rocks such as granite. In this sense "tors" are extremely frequent on the Monaro plateau at altitudes of 3000–3500 feet, in the neighbourhood of Berridale and Dalgety in particular, where they are developed on Palaeozoic granites. But not only are there many detached buns of rock and rocking stones; there are numerous stacks or "thumbs" as I have called them personally since they often have that appearance. Here these rooted projections rarely stand higher than 10–15 feet above their bases. All these features occur in great fields or *Felsenmeere*, which correspond on the whole to the higher ground in this gently undulating country, though they do occur in smaller groups on the lower parts also. Rocking stones and stacks in granites occur sporadically through Australia in a wide variety of climates and it is indeed the frequency and extensiveness of these features on the Monaro plateau, which is really distinctive, not so much the nature of the phenomena. In the Berridale–Dalgety area, elaborate castellated tors of the Dartmoor–Bodmin Moor type must be rare for I have yet to encounter anything fully comparable there. This may be due to the predominance of vertical joints as compared with flat-lying planes of weakness and perhaps also to a shallower depth of rotting. Nevertheless many of the Monaro features do, I think, fall fully within the genetic definition of "tor" given by Professor Linton, and certainly Costin attributes the stripping of the soil and rock waste from the sound rock cores to solifluction in Pleistocene time.

This area must certainly have experienced pronounced periglacial conditions when the nearby Kosciusko plateau suffered the rigours of ice cap glaciation. Though the granite Kosciusko plateau underwent mild glacial erosion compared with Western Britain, nevertheless we may note on the Snowy Mountains an absence of the tors which are so frequent on similar rocks on the lower plateau to the east. Instead we find the lower slopes are moraine-covered and the summits are strewn with fairly angular blocks of rock, exhibiting much more the effects of frost-shattering than of chemical weathering; the summit of Mount Townsend, for example, illustrates the contrast fully. Thus on a smaller scale one can parallel many of the points of Professor Linton's paper here at the other end of the earth.

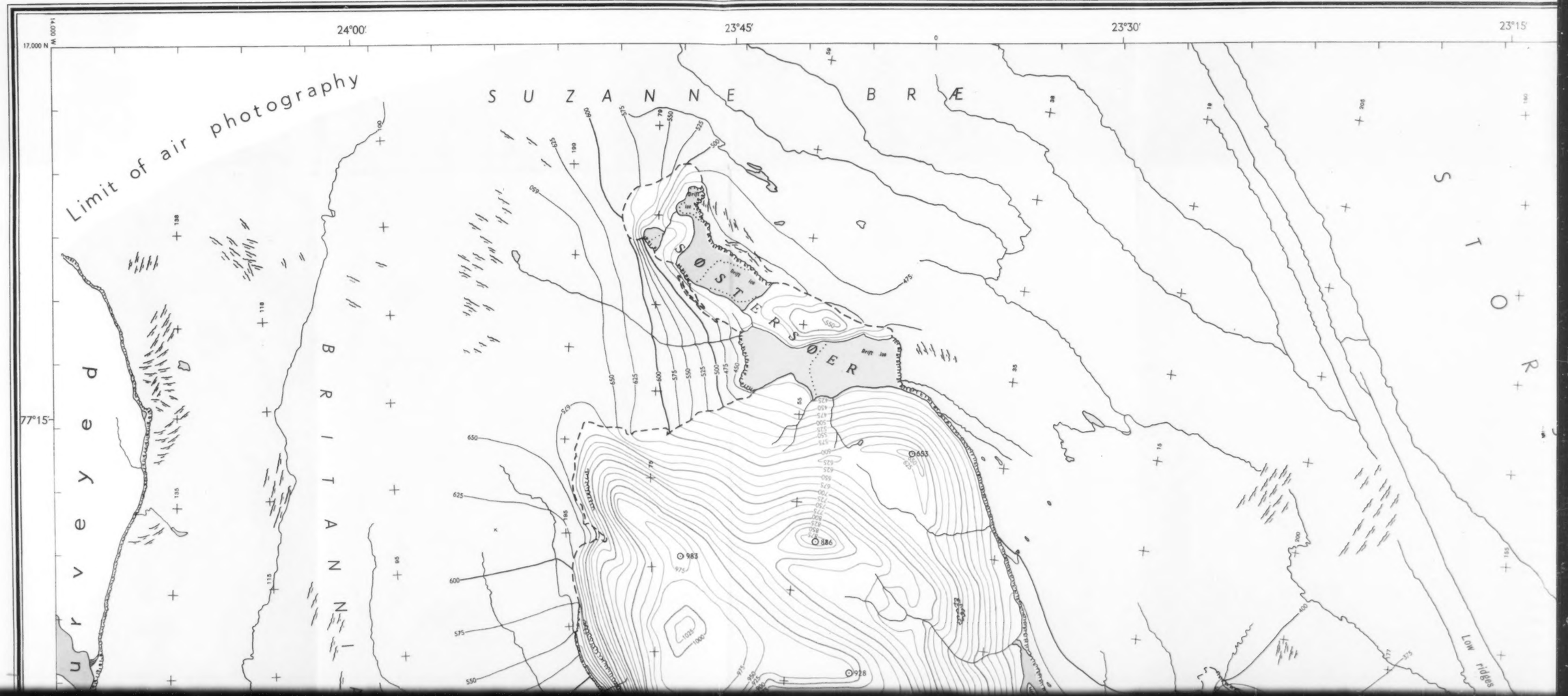
J. N. Jennings

The Australian National University,
Canberra, A.C.T.

25 *February* 1956

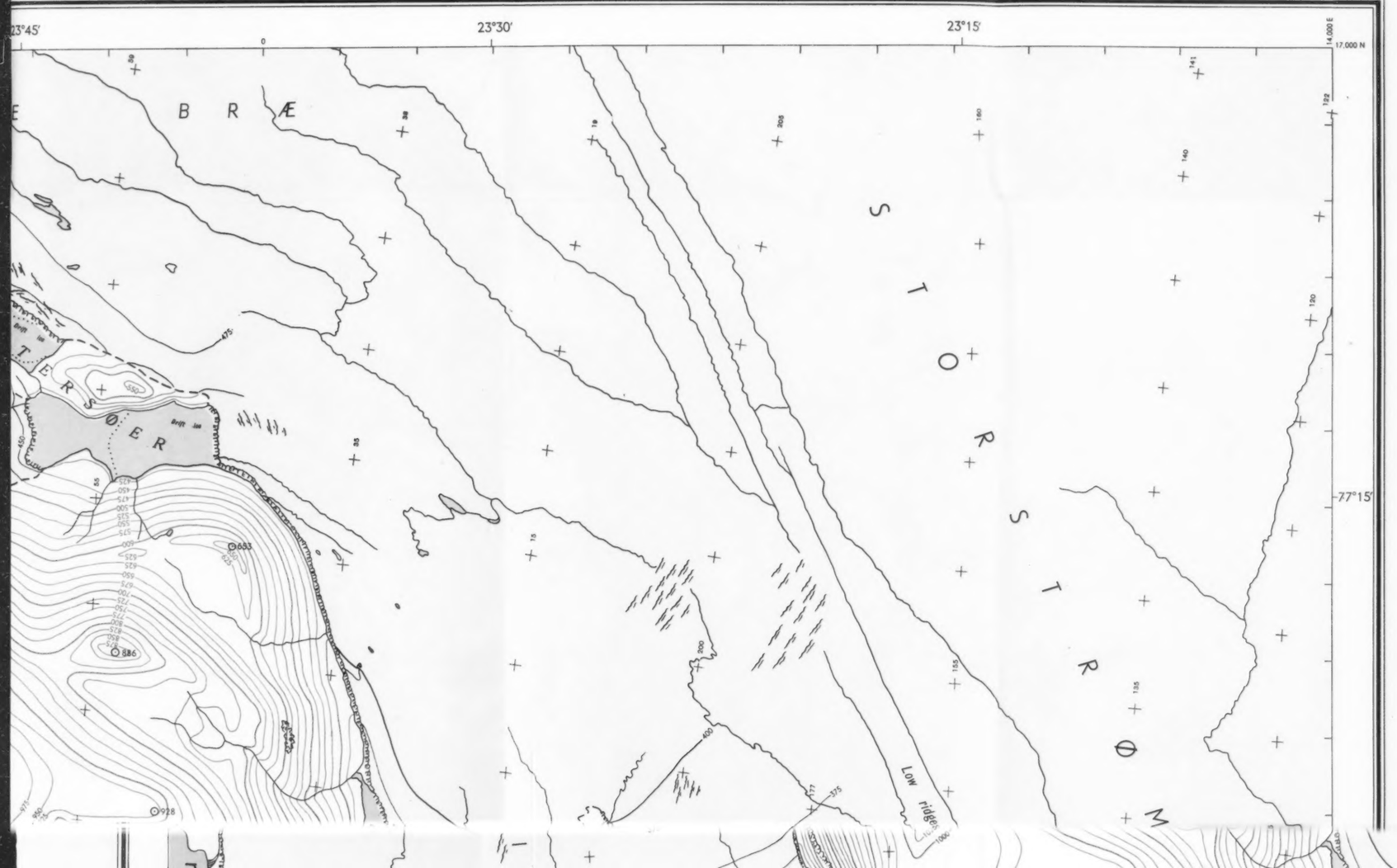
Scale 1:50,000

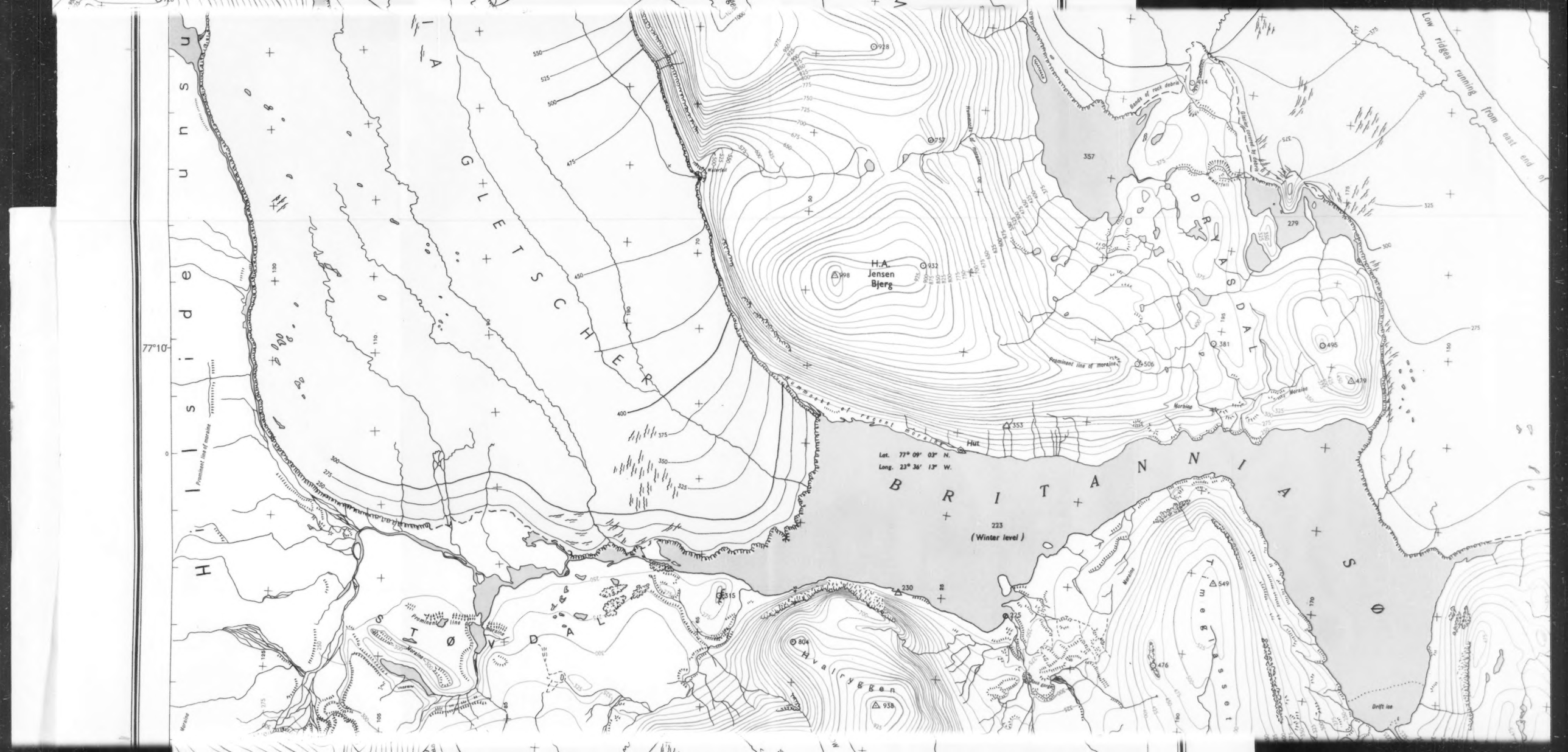
GREENLAND
NORTH-EAST DRONNING LOUISE LAND

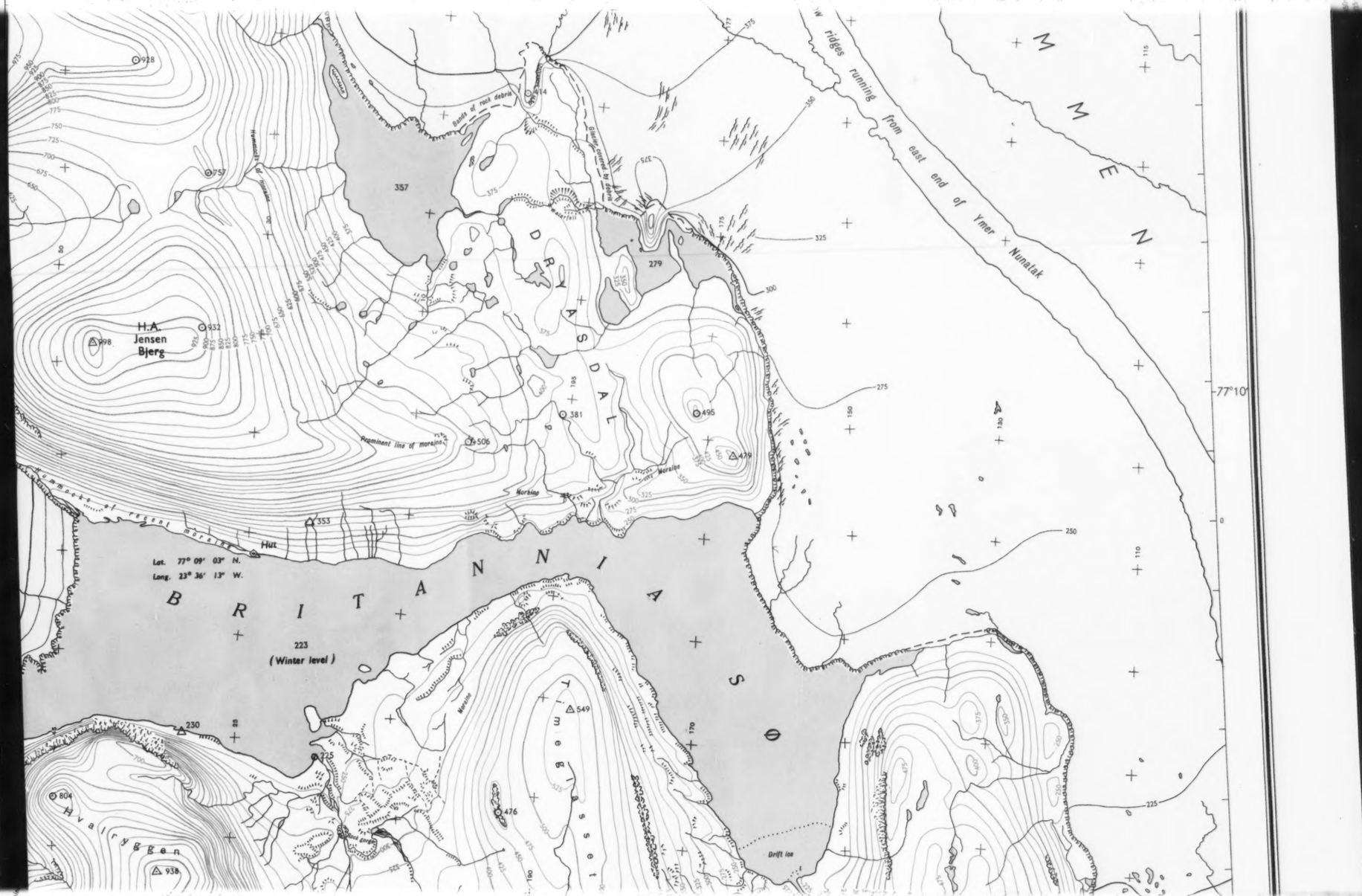


GREENLAND
-EAST DRONNING LOUISE LAND

BRITANNIA SØ




Hillside
Prominent line of moraine
77°10'
0
GLETSCHER
H.A. Jensen Bjerg
Hut
Lat. 77° 09' 03" N.
Long. 23° 36' 13" W.
BRITANNIA SØ
(Winter level)
DRYAS DAL
STØVDAL
Hvalrygen
Low ridges running from east end of
Prominent line of moraine
Moraine
Waterfall
Drift ice


H.A. Jensen Bjerg
Lat. 77° 09' 03" N.
Long. 23° 36' 13" W.
Hut
BRITANNIA SØ
DRYAS DAL
YMER Ø
Hvalrygen
Drift ice
Banks of rock debris
Prominent line of moraine
Remnants of recent moraine
Moraine
Morine
357
279
223
(Winter level)
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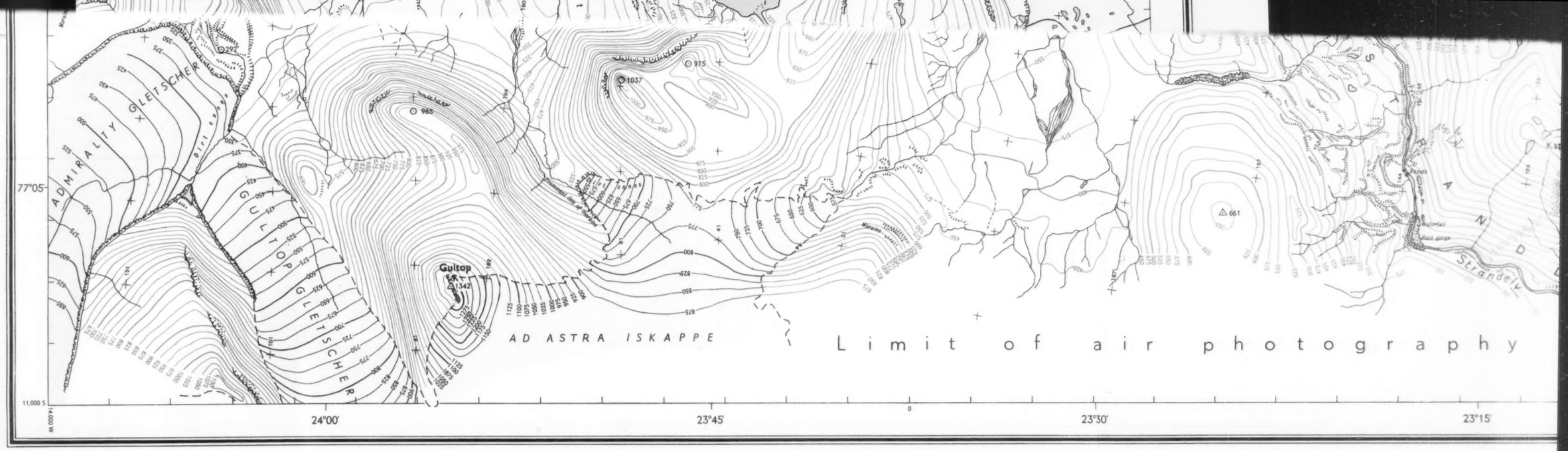
77°10'



SCALE 1:50,000

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Metres 1000 500 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Kilometres

TRUE N.

MAG. N.

At Sheet Centre

Grid North and True North are coincident.

Magnetic Variation approximately 36° West, August 1954.

Trigonometrical Station with Cairn	Scarps bordering terraces
Astronomical Station with Hut (Grid Origin)	Edge of lake on land
Resected Point with Cairn	Lake with damp earth surrounds
Spot Heights in Metres . 263	Edge of lake on glacier
Glacier edge with ice cliff	Land streams (these flow in the three summer months only.)
Glacier edge without ice cliff	Stream bed, probably dry
Main areas of badly broken ice, possibly crevassed	Glacier Streams (only few of the major streams are shown.)
Rock cliff	Form lines (on land)
Flat rock outcrop	Form lines (on glacier)

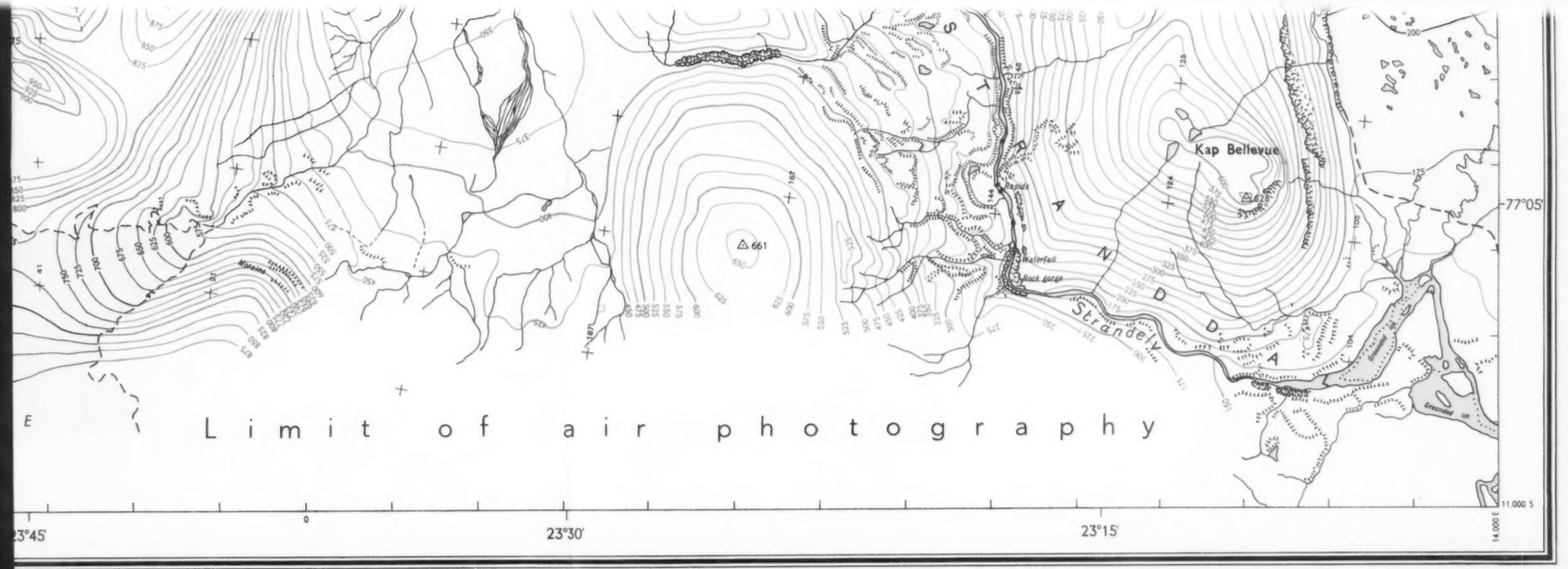
The 225 metre form line has been omitted where it surrounds Britannia Sø.

Grid and Heights in Metres

AERIAL PHOTOGRAPHY SORTIE NUMBERS.

V 230 A2 (PT I)	104-122 124-141 167-177 187-205	V 230 A2 (PT II)	1-19 21-38 41-58 61-79 81-100
V 230 A1 (PT I)	182-184 190-199		101-118 121-138

+ Principal points of photographs



Drawn at Directorate of Colonial Surveys from a survey by
K. C. Arnold and Lt. F. R. Brooke R.N.,
British North Greenland Expedition, July 1954.
Based on triangulation by Lt. F. R. Brooke, R.N., 1953-1954.
Air Photography by 230 Squadron R.A.F. August 1954
Published by the Royal Geographical Society
in the *Geographical Journal*, June 1956.

SCALE 1:50,000

3 4 5 6 7 8 9 10 Miles
5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 Yards
4 5 6 7 8 9 10 11 12 13 14 15 Kilometres

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Scarps bordering terraces
Edge of lake on land
Lake with damp earth surrounds
Edge of lake on glacier
Land streams (these flow in the three summer months only.)
Stream bed, probably dry
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V 230 A2 (PT I)	104-122	V 230 A2 (PT II)	1-19
	124-141		21-38
	167-177		41-59
	187-205		61-79
			81-100
V 230 A1 (PT I)	182-184		101-118
	190-199		121-138

+ Principal points of photographs

RELIABILITY DIAGRAM

AIR PHOTOGRAPHY AUGUST 1954
A, LIMIT OF GROUND CONTROL

MEETINGS: SESSION 1955–56

Meeting of 19 March 1956. The President in the Chair

Elections to Fellowship: Geoffrey B. Allen; Lawrence B. Armstrong; James F. Bell, B.SC.; James Bruce, M.D., B.SC.; Owen C. Douglas; Miss Marjorie Fanning-Evans; Francis P. Farquhar; Miss Eileen Gilmore; Victor M. R. Goodman, C.B., O.B.E., M.C.; Harold R. Hesketh; Norman Jones; Peter J. Lacey; John H. Leakey, M.A.; John S. le Mare; Anthony J. Light; Anthony D. Marshall; Miss Gillian E. M. Mills; Q. N. Moutafian; Robert D. Ross; Mrs. Gordon Searle; Samuel Shenton; George A. N. Starmans; Philip J. Stephenson; Major T. L. C. Tomkins; David R. White, B.A.

Elections to Associate Membership: Miss Valerie F. M. Gibbs; Michael Hollyer; Frank R. Payne.

Paper: Problems of development in New Guinea. By Professor O. H. K. Spate

Meeting of 26 March 1956. Professor J. A. Steers in the Chair

Paper: Some investigations of solifluction in Norway. By P. J. Williams

Meeting of 9 April 1956. The President in the Chair

Elections to Fellowship: Mr. Frank A. Bowater, B.A.; Mr. Donald Brierley, B.SC.; Miss E. M. Norman-Butler; Mr. George Catt; Mr. Alan Cole; Mrs. Sonia Cole; Mr. Donald Cons, B.SC.; Miss D. E. Cope; Hon. Hugo N. Money Coutts; Mrs. C. J. P. Dunsheath, B.A., B.SC.; Miss Daphne R. Edmonds; Mr. John D. Evans; Mrs. F. Armstead-Fairweather; Captain W. B. Firth; Mr. Alan Fisher; Mr. Peter D. J. Fletcher, B.A.; Mr. Charles S. Greer; Major William C. Grierson; Mr. Michael E. Hayes; Mr. Charles J. Hogg, M.A.; Mr. Robert E. Kaupp; Mr. J. J. Klawe; Mr. John Mitchell; Major N. F. Neilson; Captain Charles P. C. Noble, D.S.C.; Mr. Clifford D. Ollier, M.SC.; Mr. A. Ameer Raffo; Mr. Kenneth R. Shickle, B.SC.; Mr. John B. Thwaites; Mr. Donald A. Tremayne; Mr. Nom Upramai; Mr. Donovan R. Vickers; Mr. Lyn S. Wilson; Mr. Cyril F. Wright; Mr. P. J. Zondervan

Elections to Associate Membership: Mr. Simon Firth; Miss Christine Grebby; Mr. R. C. Treves

Election to Corporate Membership: The Mond Nickel Company Limited

Films: "South ": the film of Shackleton's Imperial Trans-Antarctic Expedition, with commentary by J. M. Wordie. "Gateway to the Antarctic": the film of Duncan Carse's South Georgia Expedition

Meeting of 23 April 1956. Baroness Ravensdale in the Chair

Film: Great Barrier Reef, and other Australian sound films

Meeting of 30 April 1956. The President in the Chair

Paper: Alps and elephants. By Sir Gavin de Beer, F.R.S.

Elections to Fellowship: Wilfred J. Adams; Rev. James P. Adkins; Mrs. Florence Chaudhari; Squadron Leader John R. Claydon; Roy William Cotton, M.A.; Herbert T. Harridge; Mrs. Kathleen B. Kay; Albert G. Kenny; William Marshall; Peter O. M. Moyse; Jack C. Pearcy

Elections to Associate Membership: George Robert Elliston; Miss Sarah A. Scott

Meeting of 14 May 1956. Captain A. R. Glen in the Chair

Paper: Oxford Expedition to North East Land, 1955. By J. T. Hollin

THE ROYAL GEOGRAPHICAL SOCIETY

KENSINGTON GORE, LONDON, S.W.7

FELLOWSHIP AND ASSOCIATE MEMBERSHIP

The object of the Society being the Promotion and Diffusion of Geographical Knowledge, it has always welcomed to its Fellowship those anxious to further this object by their interest and support, as well as those able to take a more active part in the work of discovery and exploration.

FELLOWSHIP

The Bye-Laws provide that a candidate for admission to the Fellowship of the Society must be proposed by a Fellow personally known to him and seconded by another Fellow. Further, that a candidate is not eligible until he (or she) is twenty-one years old, unless he holds a Commission in Her Majesty's Forces or he (or she) is a matriculated student of a University of the United Kingdom or the Self-Governing British Dominions. Proposal forms can be obtained on application to the Director and Secretary.

Every Fellow shall be required to pay on election *either* £4 as Entrance Fee and £4 as Annual Subscription for the current year and thereafter an Annual Subscription of £4 due on 1st January in each year; *or* a single compounding fee of £60.

The Entrance Fee and first Annual Subscription may be paid in four quarterly instalments of £2 each; *or* the Entrance Fee and first two Annual Subscriptions may be paid in four half-yearly instalments of £3 each. Thereafter the Annual Subscription may continue to be paid in four quarterly instalments of £1 each or two half-yearly instalments of £2 each respectively. Entrance Fee and Annual Subscription may be paid by instalments only where payment is made by Banker's Order. Half-yearly instalments shall be due on the 1st January and the 1st July; quarterly instalments shall be due on the 1st January, 1st April, 1st July and 1st October.

For Fellows who are under the age of 25 years on election the Entrance Fee shall be reduced from £4 to £2. The Entrance Fee and first Annual Subscription may be paid in four quarterly instalments of £1 10*s*. 0*d*. each *or* the Entrance Fee and first two Annual Subscriptions may be paid in four half-yearly instalments of £2 10*s*. 0*d*. each: thereafter payment may be by instalments as above. Entrance Fee and Annual Subscription may be paid by instalments only where payment is made by Banker's Order.

Fellows may compound for their Annual Subscriptions at any subsequent time by a payment of £60 less £2 for each Annual Subscription paid in excess of five with a minimum of £20 after 25 payments.

No Fellow shall be entitled to vote or to enjoy any privilege of the Society while in arrear.

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The Bye-Laws covering the terms of Associate Membership provide that—

1. *A candidate must be not less than 17 and not more than 20 years of age. He (or she) must be recommended by a Fellow, University or School authority.*
2. *Subscription shall be £2 per annum without Entrance Fee.*
3. *On attaining the age of 21 Associate Members become eligible for Fellowship. The Entrance Fee of £2 shall be waived provided they have been Associate Members for 3 years. Otherwise Associate Membership shall cease at the age of 21.*

All subscriptions are payable in advance, on the 1st of January in each year.

PRIVILEGES OF FELLOWS AND ASSOCIATE MEMBERS

The privileges of a Fellow or Associate Member include admission (with one Friend) to all ordinary Meetings of the Society, and the use of the Society's House, Library and Map-room. Each Fellow is also entitled to receive a copy of *The Geographical Journal*. Associate Members have the choice of receiving either *The Geographical Journal* or *The Geographical Magazine*. Associate Members may not describe themselves as F.R.G.S. and have no vote at Annual or Special General Meetings.

A pamphlet giving details of the Society and a copy of the Charter and Bye-Laws will be sent on application to the Director and Secretary.

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